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Photo by Tad Nichols, February 23, 1944

PARÍCUTIN VOLCANO AT DUSK

See *The Story of El Parícutin*, page 357

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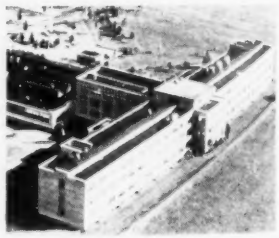

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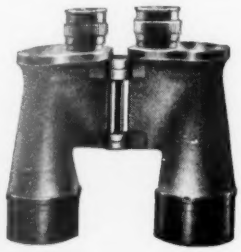

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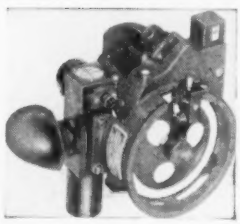

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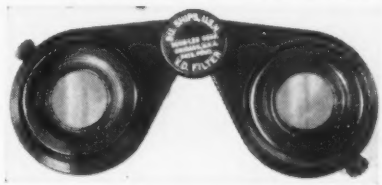

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VOL. LXV *November 1947* NO. 5

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VOL. LXV *November 1947* NO. 5

THE STORY OF EL PARÍCUTIN

By FRED M. BULLARD

The observations on El Parícutin were made in 1944 and 1945 by Professor Bullard (Ph.D., Michigan, 1928) under a research grant from The Geological Society of America and the University of Texas Research Institute. Dr. Bullard is Professor of Geology and Mineralogy at The University of Texas. A native of Oklahoma, he has spent most of his academic life there and in other parts of the Southwest.

A VOLCANO is a vent in the earth's crust from which gaseous, liquid, or solid material is ejected. Lofty cones are frequently formed by the accumulation of the ejected material around these vents. Indeed, the most lofty mountains on the face of the earth are volcanic cones. Alaska and Mexico have numerous active volcanoes, but the United States was without an active one until the explosive eruption of Mount Lassen in California in 1914. The activity of Mount Lassen extended over a period of about three years and was followed by quiescence, the only indication of activity today being the hot springs and fumaroles at the base of the cone and the gases that rise quietly from the crater. Although the number of volcanoes in North America, including both active and extinct, must number in the thousands, only two new vents have come into existence in North America in historic times. The birth of a new volcano is, therefore, an event of rather unusual significance. A volcano is essentially the result of a gas explosion, a remnant of the gas evolving process that has been going on since the earth separated from the sun. Not only does an active volcano enable us to study geology in the making, but it affords an opportunity for observational data on some of the problems fundamental to our concept of the origin and history of the earth. To be able, therefore, to study the entire life history of a volcano is indeed a rare opportunity.

Both the new volcanoes of North America are located in western Mexico. On September 29, 1759, 188 years ago, the inhabitants of Jorullo, a small Indian village southeast of Uruapan in the state of Michoacán, Mexico, were alarmed by the sudden eruption of material from an opening in a nearby field, which was being cultivated at the time. Shortly, the surrounding land was covered with ash and black cinders, which ruined the crops and caused the buildings to collapse. As the eruption continued, three extensive outpourings of lava laid waste a broad expanse of fertile land. A main cone, approximately 1,300 feet in height, and three smaller subsidiary cones were formed. After a few years (the chief activity was the first year) the eruption ceased, and no further activity has occurred at this vent. Our knowledge of the

actual eruption is from notes left by the Spanish priests who journeyed from Morelia to witness the eruption, and from the writings of Alexander von Humboldt, who visited Jorullo in 1803.

Common as such cinder cones are in Mexico—there are literally hundreds in the region—no repetition of such a dramatic event as the birth of a volcano took place until February 20, 1943, when, only 65 miles northwest of Jorullo, the second volcano to come into existence in North America in historic times was born. Named Parícutin for a small Tarascan Indian village (population, 500) $1\frac{1}{2}$ miles from the vent, it is roughly 200 miles west of Mexico City and 20 miles southwest of Uruapan, a city of 30,000 inhabitants, connected with Mexico City by a paved highway and a railroad as well as air lines. From Uruapan, taxis and buses reach the outskirts of the now lava-covered town of San Juan de Parangaricutiro, 3 miles from the base of the cone. Here, customarily, horses are obtained, and the remainder of the journey is made on horseback. The area where Parícutin Volcano appeared is a basin, about a mile and a half in diameter, bordered by volcanoes (cinder cones) on the north and east and by the high mountain mass (also volcanic) of Tancítaro (approximately 13,000 feet) on the south and west. The village of Parícutin, which is now completely covered by ash and lava, was in one edge of the basin, and the Indians of the village cultivated the land in the basin for a living.

The stories of the beginning of the volcano are varied. The first indication that something was about to happen was on February 5, 1943, when strong earthquake shocks were felt in the surrounding

Photo by Tad Nichols, July 1945

A CONTEMPORARY POMPEII

THE TOWN OF SAN JUAN DE PARANGARICUTIRO WAS BURIED UNDER 30 FEET OF LAVA IN JUNE 1944, LEAVING ONLY THE CATHEDRAL TOWERS PROJECTING ABOVE THE LAVA FIELD.

area, alarming people in towns 20 or more miles distant. These shocks continued, and on February 12 the newspaper reported 30 shocks in the nearby town of San Juan de Parangaricutiro. On February 19, 300 tremors were reported. The inhabitants of Parícutin and San Juan de Parangaricutiro were seriously alarmed by the frequency of these tremors, although earthquakes are not particularly uncommon to the region. On the morning of February 20, Sr. Dionisio Pulido, a Tarascan Indian from Parícutin, with his wife and a friend, left the village to spend the day in the basin, where he had a 9-acre plot of land. They took with them certain supplies to prepare for the spring plowing. Suddenly, as they worked, they began to hear strange rumbling noises beneath the ground; these increased in intensity during the morning and were described as similar to the roar of a freight train. A little later, Sr. Pulido and his companions saw, with great surprise, narrow columns of white gas, which they described as smoke, rising from the edges of a small depression that had just appeared in the Pulido plot. By four o'clock the small columns of gas had changed to thick black clouds, accompanied by violent explosions, dust, rocks, and red-hot fragments. Terrified, the Indians hurriedly abandoned the scene. After warning their neighbors in Parícutin, they went to report their strange experience to the authorities at San Juan de Parangaricutiro. By the time they arrived the explosions could already be heard, and the dark, dust-filled gas column could be seen rising many thousands of feet into the sky. During the night the roar of the explosions and the glare from the red-hot material kept the panicky population of Parícutin and San Juan de Parangaricutiro awake. Groups of frightened men and women gathered in the churchyard to witness the magnificent spectacle and to ponder its meaning. Early the next morning some of the more curious ventured into the basin to observe the activity at close range. On arriving at the scene they found a black cone, already 120 feet high, with an opening in the top through which hot gases, ash and cinders, solid fragments, and molten bombs were being ejected in violent explosions at intervals of one to two seconds. Dr. Ezequiel Ordonez, veteran Mexican geologist and student of volcanoes, reached Parícutin on the evening of the third day of the eruption. He describes the eruption, as he first observed it, in the following words: "Amid the almost continuous explosions I could see many tons of incandescent rocks being hurled high into the darkness of the night, and the flames attending each explosion brightly illuminated the big column of vapor and gases that were issuing from the huge vent."

During the first few weeks in the history of the volcano, the material ejected was largely fragmental, consisting chiefly of bombs (pasty masses of lava which cool in flight) and blocks (fragments of the wall rock of the conduit). The bombs ranged in size from a few inches up to masses several feet in diameter. Most of them were solid when they landed, but occasionally they were still soft enough to flatten upon impact with the ground. In addition, the eruption column, black with ash and cinder particles, boiled out of the crater like smoke from a ship's funnel and rose to a height of 15,000–20,000 feet before it spread out and drifted with the prevailing wind. From the eruption cloud there was a constant rain of ash particles, which filled the air and produced a bluish haze that gave the impression of an approaching storm. Near the base of a cone the fragments are quite coarse, but the finer material drifts many miles before it finally settles. The heaviest ash falls from Parícutin were in April 1943, when an appreciable amount fell in Mexico City, more than 200 miles distant. The tempo of the explosions varied from one

to two seconds the first few days to three to four minutes during the second and third months. Later in the first year, the interval between explosions became longer, and the explosions were more irregular than during the early months. It should be stated, however, that there was continuous activity during the first two years. During the past two years there have been periods, ranging from a few days to a week or more, during which there was little or no explosive activity in the main crater. Lava, however, has continued to flow during much of this time.

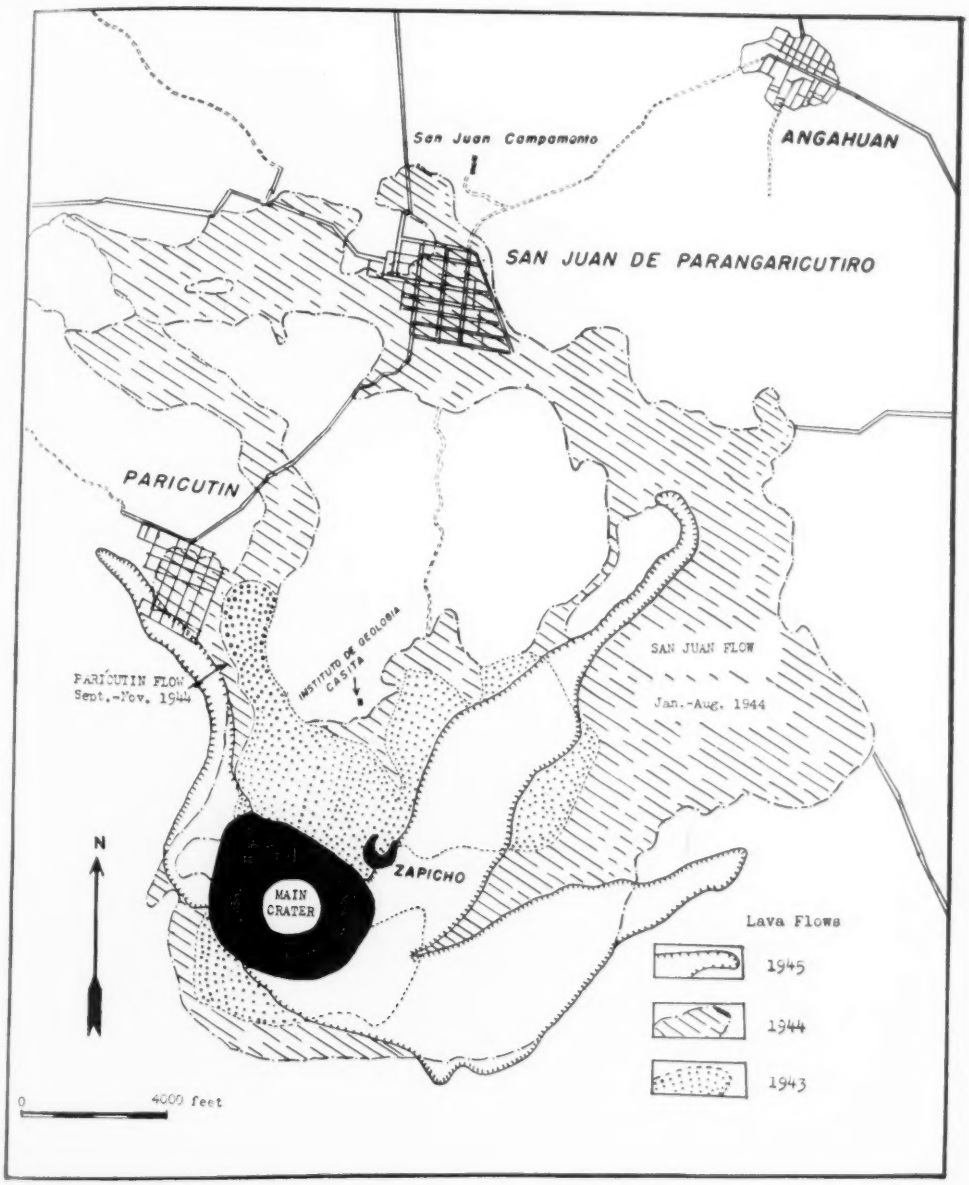
At night the volcano presents a magnificent spectacle. During the early months, when the explosions were frequent and continuous, the night spectacle was at its best. With each explosion literally thousands of red-hot fragments were thrown to a height of 2,000–3,000 feet above the crater rim, and, as they reached their zenith, they seemed to stop before beginning to fall, showering the cone like a giant skyrocket and leaving a trail of fire as they cascaded down the sides. So abundant were these fragments that frequently the entire cone was covered with interlacing fiery trails, which outlined it against the blackness of the night. The effect was complicated by the fact that in the early months four or more subsequent explosions would take place before the fragments from one explosion had landed. Thus some bombs were going up, others were just reaching their highest point, and others were falling, presenting a spectacle that held the attention of the observer for hours at a time.

During the first three months ash falls caused much inconvenience and considerable damage in Uruapan and other towns in the region. In the immediate vicinity of the volcano the ash killed the trees, filled the springs and wells, collapsed the roofs of buildings, and laid waste the land.

Photo by the author, September 6, 1944

LAVA FLOW OF SEPTEMBER 1944 ADVANCING THROUGH A FOREST

NOTE THAT THE TREES WERE FREQUENTLY PUSHED OVER AND BURIED BY THE ADVANCING LAVA.



LAVA FLOWS FROM PARÍCUTIN VOLCANO

MAIN CONE AND 1943 FLOWS FROM A MAP BY INSTITUTO DE GEOLOGÍA; 1945 FLOWS (TO MAY) AFTER WILLIAMS.

Parícutin village was soon buried by the ash and cinders, and in June 1943 only the roof tops were visible above the cover of ash. At this time the Mexican government evacuated the inhabitants, moving them to a location near Uruapan. The thickness of the ash, as mapped by Dr. Howel Williams in May 1945, varied from 10 feet at a distance of 1 mile from the cone to 3 feet at a distance of 2 miles. The greatest extent of ash is to the east of the volcano, where a thickness of 6 inches is to be found 10 miles from the cone.

The ash falls were heaviest during the

first few months in the history of the volcano, and this period may be called the cone-building stage. This stage lasted for about nine months, and during this time the cone grew rapidly. It was also at this period that the conduit of the volcano was being cleared out in preparation for the extensive lava flows that were to follow. The cone reached a height of 1,500 feet above the base in the second year, and in the fourth year (1946) it was about 1,700 feet in height.

Lava has been flowing from Parícutin almost continuously since its birth. The first lava began to issue on the second day, and with few exceptions lava has flowed from the volcano every month since that time. The first lava flow emerged from a fissure in the ground some distance from the base of the cone on the north side. Instead of the tarry, or molasses, type of lava, such as is common in Hawaiian volcanoes and in Vesuvius, the lava flow consisted of a mantle of black rubble in which red-hot spots were visible. It was moving 3–10 feet per hour, with an advancing front 750 feet wide and 15 feet thick. It continued to move for several weeks and eventually extended about half a mile from the point of origin. As is true in most volcanoes, lava has rarely flowed from the crater of Parícutin; in fact, only once during the history of Parícutin has lava flowed from the crater, and this was for a period of about two weeks in June 1943. The crater frequently contains lava, but the flows usually emerge from a fissure near the base of the cone. Most, if not all, volcanoes are located along lines of weakness, and the vent develops at some point along the fissure, building up a cone with the accumulation of the ejecta. Although lava may rise in the crater of a volcano, the pressure is usually so great that it breaks

Photo by the author, October 9, 1944

ZAPICHO, THE OFFSPRING OF PARÍCUTIN

THIS SMALL VOLCANO AT THE BASE OF PARÍCUTIN (*see map*) WAS LATER BURIED BY THE LAVA FLOWS OF 1946.

out at some point along the fissure before it rises high enough to overflow the crater lip. The point from which the lava actually issues is commonly called the *bócca*, from the Italian word meaning mouth (Spanish, *bōca*). Most of the Parícutin *bóccas* have been near the base of the cone, although in a few cases they have been as much as half a mile distant. All of them have been located either on the northeast or on the southwest side of the cone. This gives rise to the suggestion that the fissure, or zone of weakness, has a northeast-southwest trend.

If a vent develops beneath the edge of the cone, the issuing lava will carry away the overlying section of the cone. This happened in the June 1943 flow, in which a large section of the cone was carried out as surface debris on the advancing lava flow. Masses several hundred feet in height were floated along at the rate of a hundred feet or more per day. These huge "erratics" are preserved today as prominent hills on the surface of the June 1943 flow. In the June 1945 flow, the vent was beneath the cone, but near the southwest edge, and as it developed a triangular section of the cone was pushed out by the pressure of the rising lava. However, after displacing this section of the cone, the lava pushed out along the side of the displaced block, so the mass was not carried away. Considerable explosive activity may occur in connection with the development of a new vent. In October 1943 spectacular fountains of lava, accompanied by intense explosive activity, built up a cone near the northeast edge of the main cone, which in a few weeks attained a height of more than 300 feet, resembling in all respects the main cone. This little volcano was named Zapicho. Shortly, a lava flow began to emerge, and as the flow moved out it carried a wide section of the cone with it. This horseshoe-shaped, or "breached," cone was a familiar landmark at Parícutin until the summer of 1946, when it was finally buried by a succession of lava flows. Such breached cones are a common feature of the landscape in many sections of Mexico.

The cyle of events that culminates in the issuing of a lava flow probably follows a definite sequence, and when all the stages are recognized it should be possible to predict the history of a flow. As a prelude to the development of a *bócca*, the explosive activity of the central crater increases in intensity as lava fills the conduit and rises in the crater. The presence of lava in the crater is indicated by the bombs ejected and by the glow over the cone at night. There is also a correlation between the gas column and the conditions within the crater. The color of the gas column (eruption cloud) gives a clue to its composition. A heavy, black cloud is highly charged with ash particles, whereas a light, yellow column has correspondingly little ash. Not infrequently the gas column will consist almost entirely of steam and will be practically invisible, except in the early morning and late evening, when atmospheric conditions are more favorable for condensation. The explosive activity has little correlation with the gas column; or at least little correlation has been recognized. Frequently, the most violent explosions are associated with little or no gas column. It may be interesting to note, in passing, that when the gas column is highly charged with dust particles, lightning flashes are common; and the sharp, gunshot-like reports of these discharges are familiar phenomena to all who have spent much time at Parícutin. The U. S. Coast and Geodetic Survey operated a seismograph at San Juan de Parangaricutiro for several months in 1945. It was soon observed that some of the most violent explosions, which rattled doors and windows miles from the volcano, were not recorded on the seismograph. This indicates that these explosions were in the gas above the crater. There is a

growing amount of evidence to indicate that many of the explosions in a volcano are the result of the interaction of volcanic gases with the atmosphere, and that these explosions originate in the crater or in the gas above the crater.

RETURNING now to the sequence of events in the development of a *bôcca:* the accumulation of pressure as the lava rises toward the surface causes an uplift of the earth's crust. This uplift is indicated by the development of a series of tension cracks, which are prominent features on the ash-covered surfaces. I observed and mapped many of these cracks and in one case (Parícutin flow of September 27, 1944) was able to observe the cracks three weeks before the vent developed. The amount of swelling, or uplift, before the outbreak of the flow is not known, but it must be measured in tens of feet. A similar swelling, measured with tilt meters, has been recognized in Hawaii as an indication of an approaching lava outbreak. The initial outbreak of lava occurs along one of the prominent fractures. The lava usually erupts in a number of places, building up a series of spatter cones until a definite channel is established. The lava then follows the established channel, and the spatter cones become fumaroles. The lava is forced upward in many of the fractures, and, where it fails to reach the surface, dikelike intrusions result. As soon as the outpouring of lava relieves the pressure, the surface sinks, developing a troughlike depression, or graben.

A typical *bôcca* has a width of about 50 feet; the pasty lava wells up along the fracture and is squeezed out like a stiff dough. It is accompanied by much gas, and frequently large gas blisters which form on the surface of the lava burst and explode with a sharp report, followed by a hissing noise like air escaping from a tire. In some explosions, fragments of lava are blown to a height of 100 feet, spattering lava for a considerable radius. In the initial outbreak, the debris is carried away on the surface of the lava flow as erratics. In the first few hours the surface of the flow contains an abundance of such debris, usually fragments of earlier flows or portions of the main cone. The lava front advances rapidly in the early stage, and velocities up to 50 feet per minute are not uncommon at the point of emergence. As soon as the lava is exposed to the air a thin, slaglike crust forms.

The rate of flow depends on many factors, such as volume at the vent, viscosity, temperature, gradient of the surface over which the lava is flowing, etc. Velocities up to 30 feet per minute one-fourth mile from the opening, on a normal slope, have been observed, although this is far in excess of the normal rate of flow. The initial lava front is about 15 feet in thickness, and it advances on all downgrade fronts. The flow follows the slope of the ground and will, in time, come to a stream valley, which then determines its course. After the initial stage of rapid movement (feet per minute) the rate of flow decreases to feet per hour, and the thickness increases to about 30 feet. When the forward movement stops or becomes quite slow, lava tongues break out at favorable points along the margin, giving the flow a "distributary-like" pattern. These small flows in turn develop vents which, except in size, have most of the characteristics of the parent (primary) *bôcca*. They are 3–5 feet wide, and, as the lava drains from beneath the crust of the flow, the surface subsides and a trough develops over the lava channel. The marginal tongues are usually active for only a day or two, and when they stop the movement of the lava on that margin is completed. The lava coming from these small vents, like the lava from the parent vent, is squeezed out under pressure, and the surface develops a characteristic pattern,

Photo by Tad Nichols, October 19, 1944

THE VENT OF THE PARÍCUTIN FLOW

LAVA IS ISSUING FROM A FAULT MARKING THE WEST SIDE OF A GRABEN. MAIN CONE IN BACKGROUND.

Photo by the author, October 6, 1944

ANOTHER VIEW OF THE ABOVE VENT, OR *BÓCCA*

locally known as "toothpaste" lava. This type of lava is sometimes confused with ropy lava, with which it has no connection.

A lava flow will continue to be active for several weeks, a month to six weeks being typical. However, the San Juan flow, the longest and largest flow to date, began in January 1944 and was active until August 1944, although there were several dormant periods in this interval. This flow, which covered the town of San Juan de Parangaricutiro in June 1944, moved a total distance of about 7 miles.

All the lavas from Parícutin are stiff and viscous, and none of the more fluid, Hawaiian-type lavas is present. The lava seems to lose little of its temperature in the flow. Even the small marginal tongues, which are several miles from the vent and must necessarily have been days or even weeks in reaching their destination, retain approximately their original viscosity. The lava may be compared to a stiff bread dough, or perhaps to taffy candy that is ready to pull. With a long stick I was able to pull the molten material, but it chilled and became brittle the instant it was removed from the flow. Temperature measurements with an optical pyrometer gave readings at several of the vents of 1910°–1935° F. and temperatures at the front of the flow one mile away of 100°–150° F. lower. Microscopically, the Parícutin lavas consist of phenocrysts of olivine in a ground mass composed chiefly of labradorite feldspar.

The characteristics of the lava flows from Parícutin are well illustrated by the Parícutin flow that developed on September 27, 1944, while I was living in a small observation cabin about 1 km. from the south base of the cone. On September 25 and 26 the explosions were quite intense, and at night a brilliant red glow was reflected on the steam column above the crater. Following the explosions the red glow slowly faded, like the lights being turned out in a theatre. This phenomenon, together with the abundance and character of the ejected material, indicated that the crater was filling with lava. Since no lava flow was active at the time, it was expected that a new outbreak was imminent. It was not clear on which side of the cone the vent would develop, since tension cracks were common on both sides along the northeast-southwest trend. The actual outbreak came in the late afternoon of September 27. The first indication was a red glow, observed at sunset near the southwest base of the cone, on the side opposite the observation cabin. The red glow had not been there the night before, and from its brilliance it was apparent that a flow of considerable magnitude had developed. Also, the glow over the crater was gone, indicating drainage of the lava. Upon arriving at the scene the next morning, we found a large graben about 400 feet from the base of the cone. This graben, approximately 1,500 feet wide and 30–40 feet deep, extended in a southwest direction along the fault marking the west side of the graben. Prominent tension cracks had been observed in this area three weeks earlier. The vent—one of the largest to date—was about 75 feet in width, and the lava was issuing at the astonishing rate of 50 feet per minute. In addition, there was a lake of molten lava located in the depressed area about 150 yards to the east of the *bócca*. When the lava lake was first observed from a distance, it appeared to be a whirlpool, but on arriving at the edge of the pool we discovered that the lava was rising from either end of the lake and flowing to the center, where the two streams joined and disappeared in a crevasse. The line of juncture of the two currents shifted from side to side in response to variations in the velocity and volume of the two streams. After disappearing into the crevasse, the lava stream apparently flowed underground and reappeared at the vent described above. There was a large amount of gas in the lava at the so-called whirlpool

Photo by the author, September 6, 1944

OBSERVATION CABIN OF THE INSTITUTO DE GEOLOGÍA

IN THIS *casita*, ALMOST SURROUNDED BY A LAVA FLOW LATE IN AUGUST 1944, THE AUTHOR LIVED FROM AUGUST TO OCTOBER 1944. LIGHT SPOT ON THE LAVA (*lower left*) INDICATES THAT IT WAS STILL HOT.

but comparatively little at the vent, which is further support for the suggestion that the lava lake was feeding the *bócca*.

The lava, flowing westward, carried in its early stage many erratics of the San Juan flow. About one-fourth mile away the lava stream plunged into a ravine about 75 feet deep, and, as it fell over the side, it produced a most spectacular lava cascade more than 300 feet wide at its crest. The flow followed the ravine for nearly a mile, and on emerging on the relatively flat area it spread out as a lakelike mass covering the site of the village of Parícutin, which had escaped (in part) the earlier flows. The rate of advance of the lava when it crossed the main east-west street in the village at 5:00 P. M. on September 29 was 40 feet per hour.

One week later the lava whirlpool had crusted over, and on its surface were many active gas vents, small, chimney-like elevations 3–5 feet high. From the red-hot interior gas was escaping with a roar like the exhaust from a locomotive. Deposits of ferrous chloride and ammonium chloride covered the entire area, and the gas fumes, chiefly chlorine (or hydrochloric acid gas), made it difficult to approach the area except under favorable wind conditions. Some fluorine gas was also present, as evidenced by the fact that I had a camera lens etched by exposure to gas in this area. After covering Parícutin village, the lava entered the valley of a small stream, and on October 17 it joined the San Juan flow. This isolated the observation cabin, leaving it on a lava-surrounded island. Although the flow had cooled for nearly two months, it was still hot, and a crossing could be made only by a route that avoided the hot spots. The crossing selected, which later became

the route for the horse trail, was at the narrowest point of the flow, about 1 km. east of San Juan de Parangaricutiro.

When a lava flow stops its forward motion, a few days or a few weeks may elapse during which the pressure accumulates and another vent develops. This has been the history of the lava flows at Parícutin and is still the pattern of activity. There have been literally dozens of lava flows from Parícutin, all of which have been mapped in more or less detail. The results are somewhat confusing, since many of the flows are, in part, at least, superimposed. Along the north side of the cone, for example, there is fully 400–500 feet of lava, consisting of a succession of superimposed flows, and the end is not in sight since lava was still flowing in this area in September 1946.

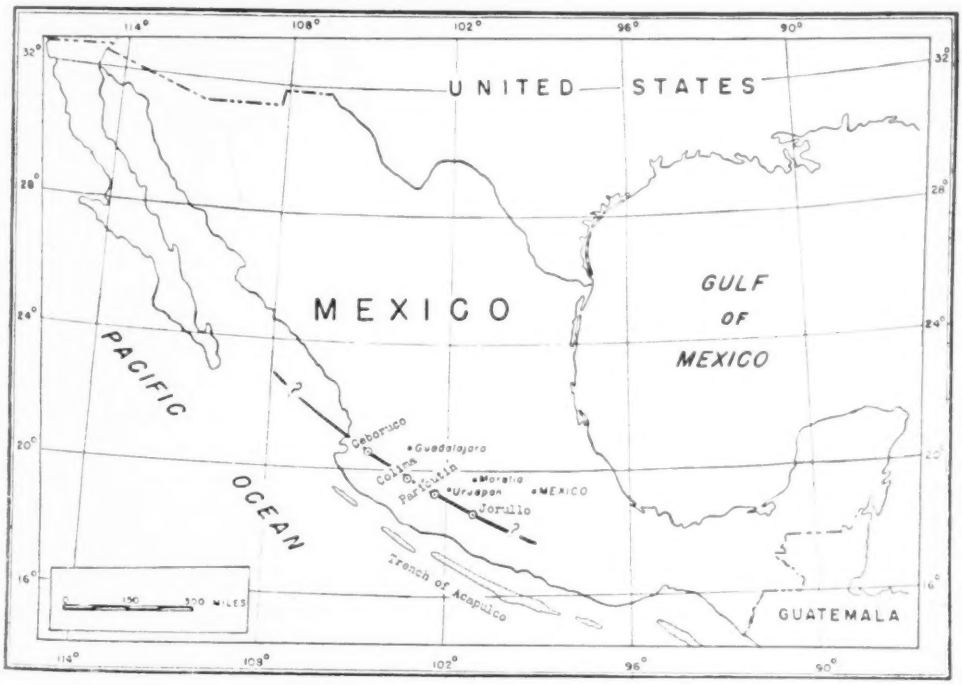
THE source of the heat in a volcano is not known, but the fact that the earth gets hotter with depth is well established by deep borings and by experiences in deep mines. The temperature gradient averages about 1° F. for each 100 feet of depth. If this gradient is constant, it is apparent that a temperature sufficiently high to melt the rocks (2,000° F.) will be encountered at a relatively shallow depth. Whether this heat is residual from a once-molten earth, or is due to radioactivity or other causes, is not known. When a mass of rock melts it expands, for rock, unlike ice, expands on melting and contracts on cooling. At the depth below the earth's surface at which the temperature is high enough to melt the rocks, there is too much pressure to permit expansion; consequently, the rocks cannot liquefy. If, however, the pressure is relieved in some manner, such as the uplifting of the earth's crust in the formation of a mountain range, local reservoirs of magma (lava) may form in those areas where the pressure is reduced. Studies of the earthquakes associated with active volcanoes indicate that they originate at a depth of about 20 miles, which is believed to be the approximate depth of the magma reservoir. Thus, volcanoes are believed to be supplied by local reservoirs of magma existing at a relatively shallow depth beneath the earth's crust.

Granting the existence of this magma reservoir, the next difficulty is to account for the force that causes the magma to rise to the surface. There are several theories; the simplest explanation is that the gases dissolved in the magma force it to rise to the surface, similar to the process resulting in the familiar "oil gusher," in which the gas in the oil is the force bringing the oil to the surface. A more homely example is the eruption of a bottle of soda water owing to the escape of the gas as a result of shaking the bottle. Explaining the origin of the gases is in itself a major problem, but, regardless of the theory accepted for the origin of the magma, some of the constituents will be in a gaseous state. As the magma cools and crystallization on the outer margin concentrates the gases in a smaller and smaller remaining liquid portion, pressure is built up that must in time force an opening to the surface at the weakest point in the roof of the magma chamber. The weakest point will be on a fracture line along which movement of the earth's crust has occurred with the uplifting of the mountain range. The alignment of volcanoes in "trends" is a result of the localization of the vents along these faults. A sinking of sections of the earth's crust in adjacent areas is a common accompaniment of a volcanic eruption. The sinking doubtless compensates for the great volume of material ejected; it also exerts pressure, which may be a contributing factor in causing the magma to rise to the surface.

To appreciate the significance of the location of Parícutin and Jorullo and to better understand their relationship to the other volcanoes of Mexico, a brief

sketch of the geologic and structural history of the region is necessary. The surface features of Mexico are largely related to the geologic history of the region since Cretaceous time. During much of the Cretaceous a broad seaway covered most of Mexico, creating a shallow basin into which was deposited a thick succession of limestones and shales. The uplift of the region at the end of the Cretaceous, in common with the formation of the Rocky Mountains, folded and faulted these sediments, leaving them in a twisted and contorted condition, as may readily be seen in the many roadside cuts along the Pan-American Highway to Mexico City.

In Tertiary time this rugged land area was worn down to a low plain, the elevation of which formed the Mexican plateau (Mesa Central), which in its present condition may be described as a great tilted block, the uptilted end along the nineteenth parallel, and the depressed end along the Rio Grande at the northern border of Mexico. The margins of this great plateau are marked by prominent mountain ranges, partly the result of folding and igneous activity, but largely caused by deep dissection of the margins of the elevated block. On the east is the Sierra Madre Oriental, which affords such magnificent scenery along the Pan-American Highway after one leaves Tamazunchale en route to Mexico City. The western margin, marked by the impressive Sierra Madre Occidental Range, separates the Pacific slope from the plateau area of Mexico. Between these two mountainous borders is the great Mesa Central, standing 7,000–8,000 feet above sea level at its southern edge and sloping northward to about 4,000 feet above sea level along the Rio Grande at the northern border of Mexico. The Mesa Central is abruptly chopped off on the south in an east-west line that follows approximately the nine-



THE TRENCH OF ACAPULCO AND ASSOCIATED VOLCANOES

PARALLELING THE TRENCH, VOLCANOES (SHOWN ALONG THE BLACK CURVE) WERE ACTIVE IN HISTORIC TIMES.

teenth parallel and passes near Mexico City. To the south of this line, the structural trend, as revealed in the mountains of the states of Chiapas and Oaxaca, shifts abruptly to an east-west direction, whereas to the north in the plateau section the trend as revealed by the Sierra Madre Oriental and Sierra Madre Occidental is generally north-south. The rocks also change radically to the south of this line, being largely ancient schists and gneisses and other metamorphic rocks, quite unlike the Cretaceous limestones and shales to the north. The folds in the area to the south are related to the structural features of the West Indies and the Caribbean rather than to those of North America.

The great volcanic peaks of Mexico are located along the line that separates the Mesa Central from the area to the south, roughly corresponding to the nineteenth parallel. Beginning on the east, some of the better-known volcanic cones are: Pico de Orizaba (18,701′), the highest peak in Mexico; Popocatepetl (17,887′), the second highest peak in Mexico; Ixtacihuatl (17,342′); Nevado de Toluca (15,020′); and Volcán de Colima (12,661′). Hundreds of other lofty volcanic cones occur along this belt, but the ones listed are the best known.

There were two periods of vulcanism in the Tertiary of Mexico: the first was in the Miocene and affected all Mexico; the second, beginning in the Pliocene, was limited to the east-west line of volcanoes described above. It has been generally assumed by most writers that Parícutin Volcano is related to this same east-west trend. Its location, although near the Pacific Ocean, is in this belt. The only volcanoes in Mexico that have had eruptions of more than fumarolic character in historic times are Colima, Jorullo, Ceburoco, and Parícutin, all located along the western end of this so-called trend and near the Pacific Ocean.

A deep trough in the Pacific Ocean, a short distance offshore and parallel to the Mexican and Central American coast, has been known for a number of years. Recent studies show that this trough consists of two parts: the northern part, called the Fosa de Mexico (the deepest portion is designated as the Trench of Acapulco), is adjacent to the section of Mexico in which the active volcanoes are located; the southern part, off the Guatemala–Salvador coast where other active volcanoes occur, is known as the Trench of Guatemala. It is of interest to note that similar troughs are also present off the Alaskan coast, adjacent to the active volcanoes of the Aleutians, as well as off the coast of Japan and elsewhere around the Pacific margin where active volcanoes are found. Furthermore, the trough area off the Pacific coast of Mexico is the center of many earthquakes, indicating that it is still an active zone. The evidence strongly suggests that Parícutin is related to a trend parallel to the Pacific Ocean, and that its alignment with the older, now-inactive, volcanoes of the east-west trend in Mexico is a coincidence. Hobbs has recently supported this idea and further contends that Parícutin Volcano is related to a new mountain range now rising along the Pacific coast.

A question frequently asked is, How long will Parícutin continue to be active? Certainly no one is able to answer this question with any degree of assurance, but certain information is available that may bear on the matter. Since volcanoes continue to grow as long as they are active, size is a measure of age. The age of such lofty peaks as Popocatepetl must be measured in tens of thousands of years; that of the small cinder cone of Jorullo, in a few months. Because Jorullo is in the same area and similar in character, it was reasonable to expect that Parícutin would follow the same pattern. Parícutin has already surpassed Jorullo in length of life, size, and volume of lava extruded, although we have

no reason to believe that it will continue to be active indefinitely. The magma reservoir beneath Parícutin may well be the same reservoir that Jorullo tapped (or for which Jorullo served as a safety valve) nearly 200 years ago. When the gas pressure in the reservoir is reduced, Parícutin will cease activity; and when the next outbreak occurs some 200 years from now (if the same pattern is followed), the vent may be another cornfield many miles from the present one. With careful study and constant observation and with the equipment now available, scientists should be able to predict not only the approximate time but the exact spot of the next eruption.

NEW ENGLAND STONES

By Winifred Duncan

Big as bare breasts they round up through the moss;
Breasts of a giantess, grey and rough with time.
Veining them, lichen and vine
Make a design.

Always the ground slopes downward from their curves
Down to the hollows where the cedars stand
Black in the sun, where the white birches run,
Hand in hand.

These are the hollows that the glacier made
Back in the dark days when the earth was young.
With a cold lip, licking and rounding stones
To make her bones.

Down the long hills her rivers ran like arms,
Carving the mountains, scraping flat the marsh.
Now all is wreathed in mist of leaf and flower;
Nothing is harsh.

On her round shoulders, on her curving thigh
The poet dreams; ants run; the spider-race
Spins delicate webs, and the fly
Washes his face.

Illusion of safety! So soon have we forgot
The past of mother earth? We suck and ravage
A creature made of cataclysms savage!
She is grown old, and close the great stars swing
To blast us from these tired breasts
Where frantically we cling.

HITCHING OUR COUNTRY TO THE STARS

By REAR ADMIRAL LEO OTIS COLBERT

Having devoted his entire professional career to the U. S. Coast and Geodetic Survey, Admiral Colbert (Sc.D., Tufts) knows whereof he writes. He has been navigator and executive and commanding officer of Survey ships in the coastal waters of the United States, Alaska, and the Philippines. During World War I he served as Lieutenant Commander on the U.S.S. Northern Pacific, *a troop transport. In 1931 he was engaged in a comprehensive hydrographic survey of Georges Bank, utilizing advanced methods of offshore surveying. Since 1938 Admiral Colbert has been Director of the Coast and Geodetic Survey.*

WHERE in the world are we? How deep is the ocean? How high is high water? Finding the answers to these questions has been the job of the Coast and Geodetic Survey during more than a century of surveying and charting our coastal waters, and of establishing geodetic control in the interior of our country. The close relationship that exists between surveys and charts and the stars and planets is perhaps not generally known; yet astronomy is at the very foundation of all surveying operations that deal with extensive areas and that require an accurate orientation on the surface of the earth. Astronomy is the medium by which we hitch our planet to the stars and to the other planets. The engineer, the surveyor, the navigator—who deal with practical astronomy—all owe a debt to the theoretical astronomer, whose determinations of the motions of the heavenly bodies and whose formulation of tables expressing their projected positions on the celestial sphere furnish data for use in establishing position on the surface of the earth—be it of an engineering structure on land, a lighthouse on the coast, or a vessel at sea.

ASTRONOMY AND THE COAST SURVEY

It is an interesting fact that at the time of the inception of the Coast Survey in 1807, there was not a single working observatory in the country for the training of astronomers, and there was not a college in the United States that included a course in geodetic surveying in its curriculum. This is but one example of the magnitude of the task that faced Professor Ferdinand R. Hassler when he accepted the commission from President Jefferson to direct the survey of our coast.

One of Hassler's first hurdles involved astronomy. Being a man of outstanding scientific attainments, Hassler planned a survey along lines of lasting worth and proved value. There were many in those days who saw no need for elaborate base measurements and triangulation systems and who advocated that the surveys of

FERDINAND R. HASSLER
FIRST SUPERINTENDENT OF THE COAST SURVEY.

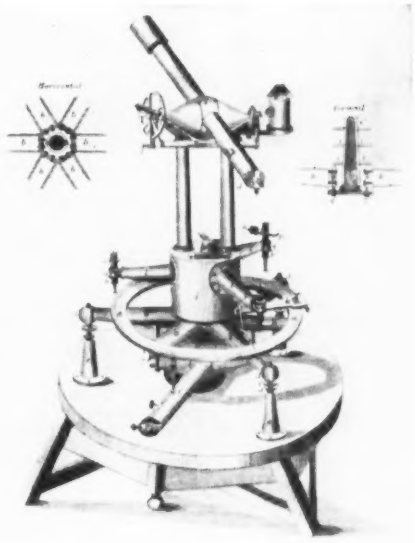
our coast be controlled by astronomic determinations alone. Hassler understood clearly that accurate surveys of extensive areas could only be accomplished by the geodetic process, which is, properly, a combination of the astronomic and the geodetic. Fortunately, Hassler's scientific approach prevailed, and the plan he proposed became the model for our work.

Some of Hassler's contemporary workers and a number of those who followed him were among the foremost astronomers in the country, and their contributions, in both methods and equipment, to the development of practical astronomy are indelibly engraved in the records of Coast Survey achievements.

In 1834 Captain Andrew Talcott, of the Corps of Engineers, discovered the differential method for the determination of astronomic latitude with the zenith telescope. Through its adoption and refinement by the Coast Survey, the Talcott method received great impetus toward world-wide use. The accuracy of the results obtained by this method is superior to that of every other field method and compares favorably with the results obtained with the largest observatory instruments.

The application of the Talcott method for determining latitude indicated some radical errors in the published star places. The various observatories of the country immediately undertook the necessary additional observations to furnish more accurate star places; so that one of the by-products of the method was an improvement in the star catalogue.

In the early history of the Coast Survey, the determination of astronomic longitude was one of the important problems that required solution. In those early days longitude was determined by observing certain celestial phenomena, such as the eclipses of Jupiter's satellites and the occultations of stars by the moon, which occurred everywhere at the same instant



ZENITH TELESCOPE
FOR DETERMINING ASTRONOMIC LATITUDES.

of time. The most practical method, and the one which gave the best results, was the use of highly accurate timepieces known as chronometers. A number of these were used to compare the difference in time between the two places where the observations were being made for difference of longitude. To minimize any error in rate, the chronometers were transported back and forth between the stations.

Within a few months after Morse flashed his first telegraphic message over the wires between Baltimore and Washington, Professor Bache, who succeeded Hassler as head of the Coast Survey, began experiments for an application of the telegraph to longitude determinations. On October 10, 1846, the telegraphic method was put into successful operation, and time signals were exchanged between Washington and Philadelphia.

The determination of longitudes by this method was extended to other parts of the country as rapidly as the electric telegraph came into practical use. Although this established a coordinated network of these accurately located points, it still

left the longitude relationship of America with the prime meridian through Greenwich, England, dependent upon chronometric determinations.

Between 1849 and 1855 the Coast Survey instituted expeditions to exchange chronometers between Cambridge, Mass., and Liverpool, England. In the last year six voyages were made, three in each direction, and fifty chronometers were transported.

Upon the completion of the first successful Atlantic cable in 1866, the Coast Survey, under the direction of Dr. Benjamin Gould, the noted astronomer, organized a project making use of the cable to measure the difference of longitude between Greenwich and the Naval Observatory at Washington. The results proved that the chronometric determination of 1855 was in error by over a second of time, or about .25 mile.

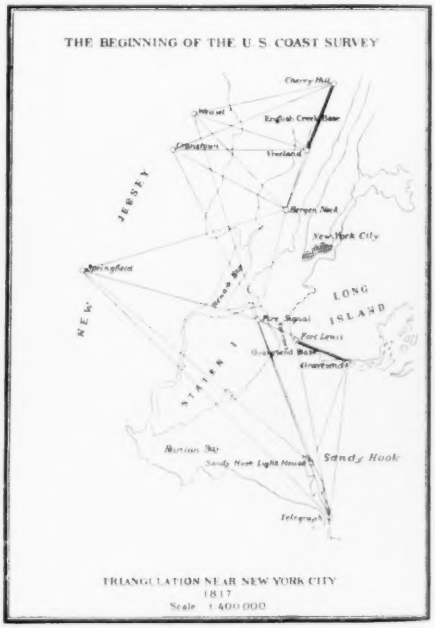
The perfection of the methods used in the United States for determining latitude and longitude placed this country well in the forefront of astronomic achievement. It was freely stated at the time that geographical values of the positions of the principal astronomic stations of the Coast Survey were determined with greater accuracy than the values known for any European observatory.

The introduction of the radio method of determining longitude in 1922 did not increase the accuracy of the results, but merely made the determination more convenient and more economical.

In recent years, important contributions to practical astronomy have been made by international cooperation in which the Coast and Geodetic Survey has participated. One of these has been the establishment of a world longitude net for the coordination of longitude work throughout the world; another, the establishment of variation of latitude observatories at five places around the world on approximately the same parallel of latitude. In this country these observatories are at Gaithersburg, Md., and Ukiah, Calif. The results furnish information for the study of the wanderings of the geographical pole.

TRIANGULATION

When the geodetic surveyor has located a survey point on the surface of the earth from astronomic observations, he has established a starting point for his land operations. The next step is to determine the direction to a second station by an observation on Polaris or other celestial body for azimuth. The third is to make an accurate measurement of the distance between the two stations. These provide the foundation for a method of locating other points on the surface of the earth without making direct measurements. This method is known as triangulation. It is the only feasible method of measuring great distances with a high degree of accuracy, independent of the character of the intervening terrain.

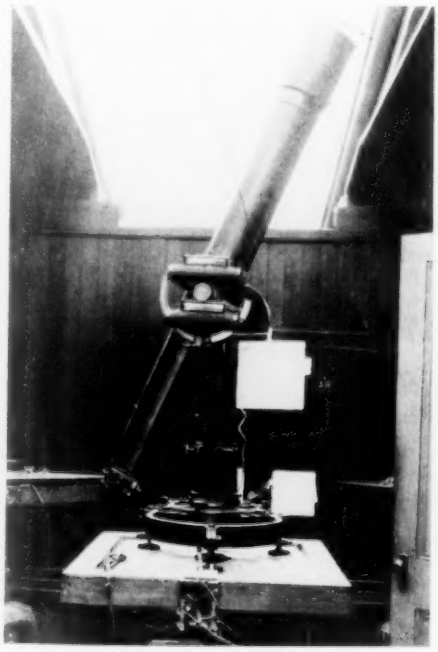


FIRST COAST SURVEY

FROM AN ACCURATELY MEASURED BASE LINE (SHOWN BY HEAVY LINES) AND THE MEASURED ANGLES OF A SERIES OF CONNECTED TRIANGLES, THE LENGTHS OF THE OTHER LINES ARE DETERMINED.

The earliest triangulation work in the United States was executed in 1817 in the vicinity of New York City. It was here that Professor Hassler made his first astronomic observations. In his report Hassler says: "A special station was made upon Weasel Mountain for latitude and azimuth, and a solar eclipse occurring just at the same time gave occasion for an observation of longitude at the same place."

Since this early triangulation, an elaborate network has been extended over the entire country, and tens of thousands of control points have been established. These are permanently monumented with markers for use as starting points in surveys for topographic, geologic, and other forms of mapping, and for every engineering project requiring an accurate knowledge of the horizontal relationship between points on the earth's surface.



24-INCH THEODOLITE

THIS INSTRUMENT USED BY PROFESSOR HASSLER IN THE EARLY TRIANGULATION REQUIRED A SPECIAL HORSE-DRAWN CARRIAGE TO TRANSPORT IT FROM ONE STATION TO ANOTHER. THE STREAMLINED THEODOLITES OF TODAY CAN BE CARRIED BY ONE MAN.

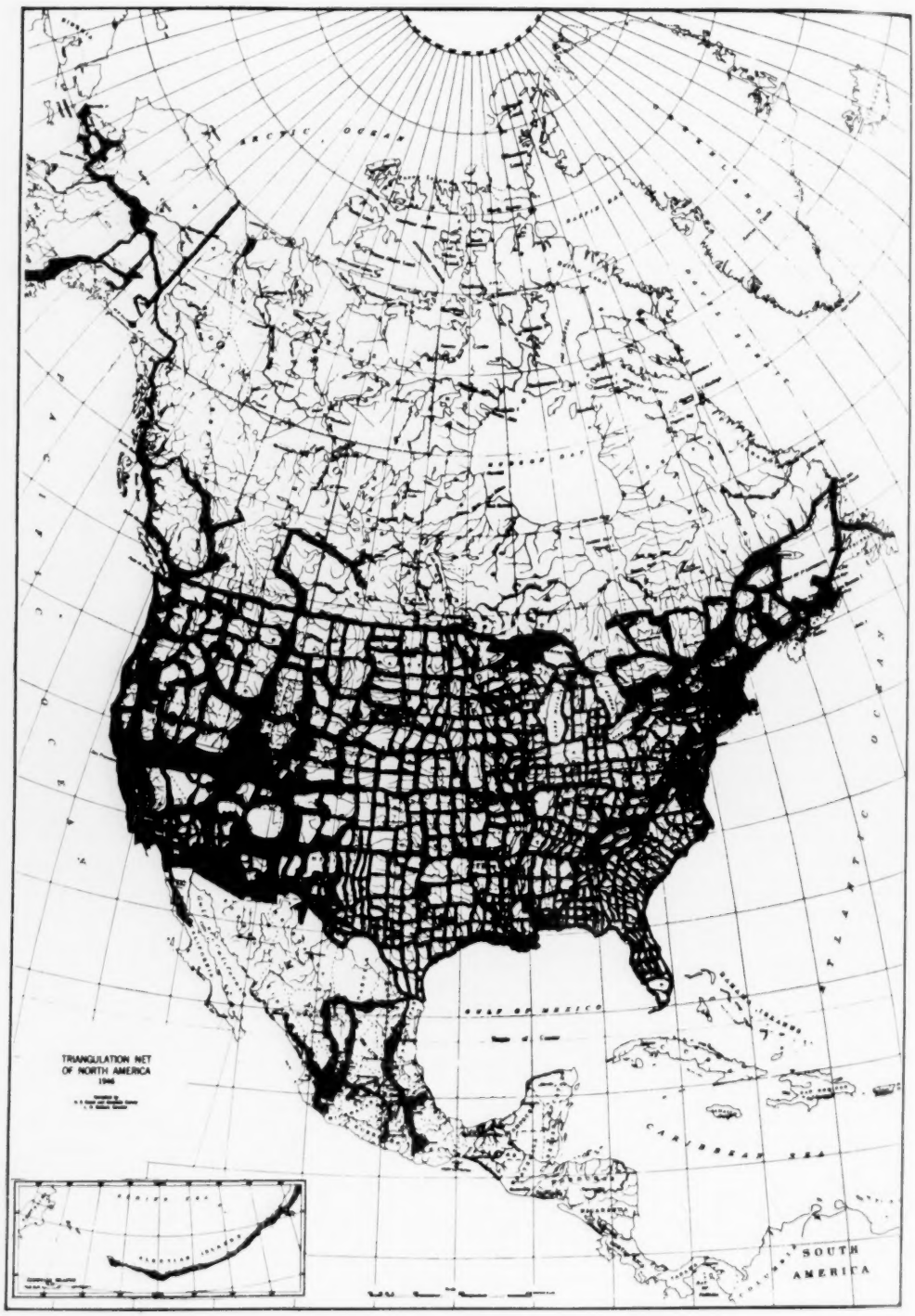
Courtesy Wide World Photos

TOP OF THE MONUMENT

TRIANGULATION PARTY MAKING OBSERVATIONS FROM THE TOP OF THE WASHINGTON MONUMENT, WASHINGTON, D. C. (555 FEET HIGH), IN ORDER TO FIX ITS POSITION IN LATITUDE AND LONGITUDE. NOTE THE COMPACTNESS OF THE MODERN THEODOLITE AS CONTRASTED WITH THE ONE USED BY HASSLER.

The shape and size of the earth must be taken into account in the survey of a country as large as the United States; otherwise, serious errors will be introduced in the results. To determine curvature, astronomy again enters the picture.

From many precise measurements involving astronomic observations and triangulation, the earth has been found to approximate closely the mathematical figure known as the oblate spheroid, with a polar diameter about 27 statute miles less than its equatorial diameter; hence, a spheroid of reference has been adopted for correctly placing the network of triangulation. The adopted reference spheroid deviates from the true figure, and this deviation is greatest in the vicinity of the high mountain ranges and the great ocean deeps. It is because of these deviations that position determination by astronomic observations alone is unsatisfactory. Many cases are on



TRIANGULATION NET OF NORTH AMERICA

THE DOMINION OF CANADA AND THE REPUBLIC OF MEXICO ARE CONNECTED BY TRIANGULATION TO THE UNITED STATES AND ALASKA TO FORM ONE OF THE LARGEST CONTINUOUS ARCS IN THE WORLD.

record of such deviations, one of the most pronounced being on the island of Puerto Rico, where a high mountain range runs east and west the length of the island, with the deep waters of the Atlantic to the north and the Caribbean to the south. Astronomic stations had originally been established on the north and south coasts of the island. When these were connected by triangulation, the true distance between them was found to be about 1 mile less than that given by the astronomic determinations.

In any engineering or scientific undertaking involving a large area, it is important that a full coordination and correlation be secured of the surveys, maps, and charts affected. A hydrographic or topographic feature on the earth can have but one latitude and longitude, which must be the same on every map or chart on which it appears. This can only be accomplished through the adoption of a single horizontal datum for the triangulation points in the country.

In the United States the origin for all Federal mapping is station Meades Ranch in central Kansas. Its latitude and longitude on the reference spheroid were fixed by a mathematical adjustment based on a study of numerous astronomic stations throughout the country that had been connected by a continuous system of triangulation.

Station Meades Ranch was selected because it was near the geographical center of the United States and because it was at the junction of two great arcs of triangulation, one along the thirty-ninth parallel and the other along the ninety-eighth meridian.

Today the continent of North America, from the lower end of Mexico through the United States, Canada, and Alaska to Bering Strait, is coordinated on this single datum. In this network is contained the longest arc of continuous triangulation in the world.

ORIGIN FOR U. S. MAPPING

STATION MEADES RANCH IN CENTRAL KANSAS IS THE ORIGIN OF THE NORTH AMERICAN DATUM OF 1927, TO WHICH ALL FEDERAL MAPPING IS TIED. MANY THOUSANDS OF CONTROL POINTS, PERMANENTLY MARKED WITH BRONZE DISCS SET IN CONCRETE, FURNISH STARTING POINTS FOR LOCAL SURVEYS AND ENGINEERING CONSTRUCTION.

The control points that the geodetic engineer has established along the coasts and in the interior of the country are used by the topographic engineer as the framework for his map. The details he fills in with the plane table or by the more modern method of aerial topography. Photographs taken from the air are reduced to map form by means of specially designed stereoscopic plotting instruments.

MAPPING THE OCEAN FLOOR

Just as without astronomy our land surveys could not be properly positioned on the surface of the earth, so it is with surveys of the water areas. The same fundamental problem is involved, although there is a difference in the methods and instruments used. When the navigator leaves the shores of one country and sets out for the ports of another, he has nothing to guide him over the trackless sea except the stars and his chart. Whether he de-

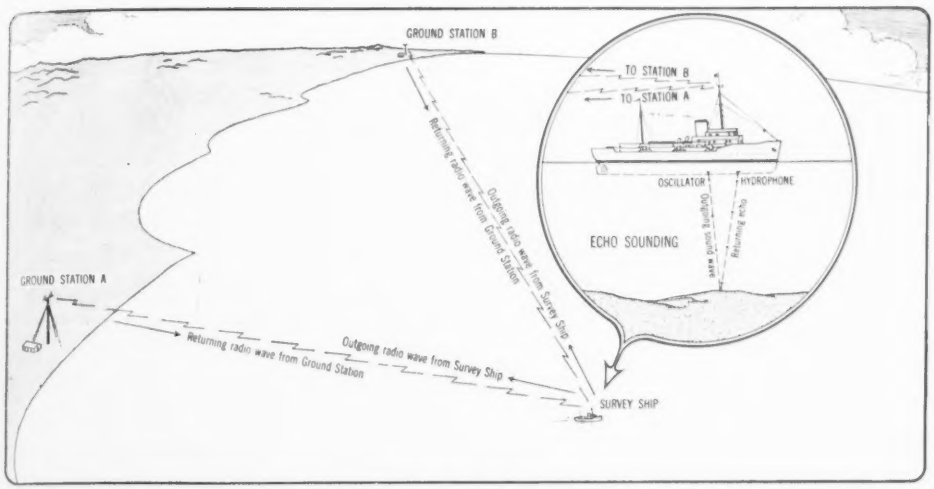
9-LENS STEREOCARTOGRAPH

DESIGNED IN THE COAST AND GEODETIC SURVEY FOR STEREOSCOPIC PLOTTING OF TOPOGRAPHIC MAPS FROM 9-LENS AERIAL PHOTOGRAPHS.

termines his position at sea by observations on terrestrial objects or celestial bodies, or by electronic methods, he must have a chart on which he can properly relate that position to the land area and to the surrounding submarine features. The foundation for the nautical chart must therefore be hydrographic surveys that are tied into the same system of spherical coordinates as is used in establishing control points on land and in delineating the topographic features.

Hydrographic surveying involves a measurement of depth and a determination of position. The revolutionary advances made in this field during the past two decades have had a profound effect on the usefulness of the nautical chart. The measurement of depths by hand lead and wire has given way to measurement by sound—better known as echo sounding. In this method depths are registered automatically on a graduated dial and can be read with equal facility whether measuring a depth of 2 or 2,000 fathoms of water. Graphic recorders are rapid and sensitive enough to detect and record wrecked ships lying on the ocean floor.

Determination of a depth has little value unless the latitude and longitude are known, so that the depth can be shown on the field survey sheet or on the published chart. When in sight of land the position of the survey vessel is determined by means of the well-known three-point fix method from sextant angles taken on board ship to objects on shore previously correlated with the coastal control net. Beyond the limit of visibility of shore objects, underwater sound ranging has been used. By exploding a bomb in the water near the survey vessel, measuring the time of arrival of the sound impulse at two or more previously located hydrophone stations, and employing the knowledge of the velocity of sound in sea water, the distance to the



ECHO SOUNDING AND ELECTRONIC POSITION DETERMINATION

WHILE THE SHIP'S FATHOMETER MEASURES THE DEPTHS UNDER THE VESSEL BY SOUND, THE POSITION OF THE VESSEL IS DETERMINED BY ELECTRONIC METHODS.

vessel can be determined. Used in conjunction with this method is the taut-wire sun-azimuth traverse. The distances between buoys are measured by means of a taut-wire apparatus, and the azimuths or bearings are determined from observations on the sun.

Occasionally it is desirable to begin a hydrographic survey at the offshore end and work in toward shore. Such was the case with the Georges Bank Survey begun in 1930. Georges Bank is an important area to both the fishing and the shipping industries. In order to modernize the charts of the Bank as early as possible, it was desirable to begin the survey near the offshore end of the Bank, about 200 miles from Cape Cod, where the westbound shipping lanes cross the continental shelf. The basic position for the project—which comprised an area of about 28,000 square miles—had therefore to be an astronomic one.

A buoy was anchored near the outer edge of the Bank and its position determined by a long series of star observations from the surveying vessel anchored nearby. Eighteen sets of sights were made by three observers on eight days, each set consisting of four or more stars. The position obtained was held fixed for the entire survey, which covered a period of three working seasons. From it, additional control buoys were established by acoustic methods and by sun azimuths. When the connection was made with the coastal triangulation, the error in the system was found to be less than .25 mile—a result far better than was expected when the survey was begun.

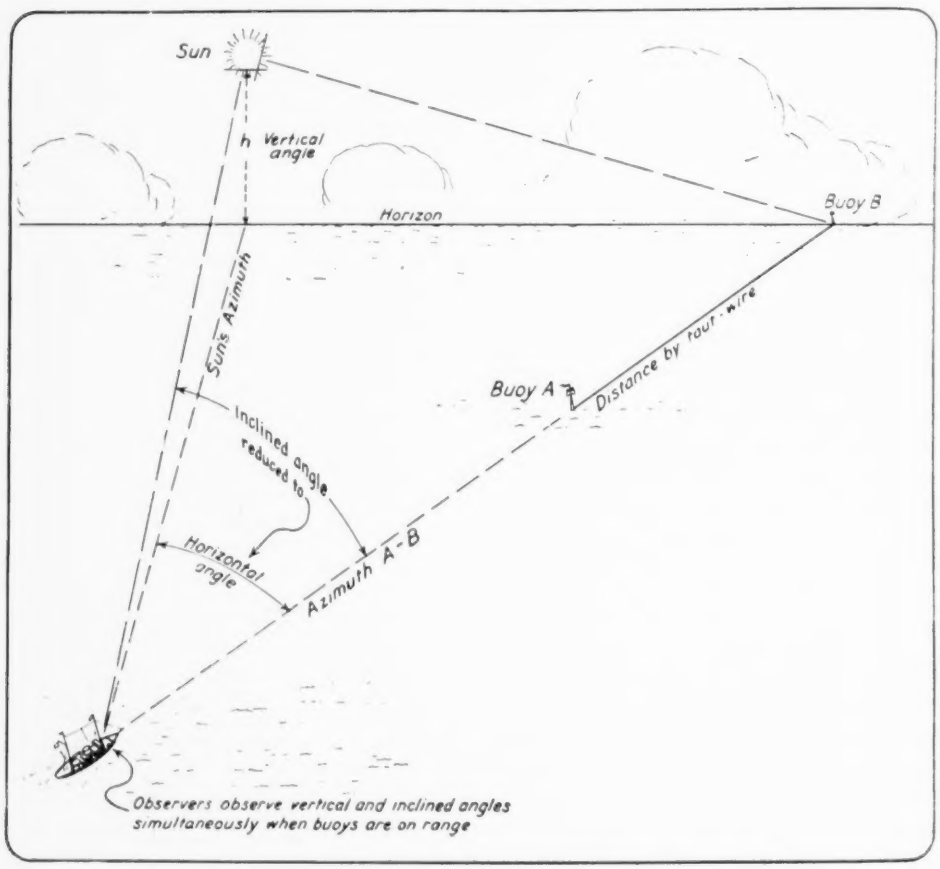
Astronomic sights are used in hydrographic surveying in the same manner as in navigation, except that they are taken with greater precision and care. An observed altitude on a heavenly body determines a circle of position on which the observer is located. Observations made on two or more stars suitably spaced around the horizon define circles of position, the intersection of which determines the position of the observer.

Acoustic methods of surveying have steadily pushed seaward the frontiers of accurate hydrographic surveys and have been used to explore the intricate patterns of our deep coastal slopes. These methods are responsible for the discovery of many

new and amazing facts about the continental shelf, the seaward extension of the land mass. The continental shelf is not of uniform width. Off certain portions of the Pacific Coast and Alaska it is quite narrow, whereas along the Atlantic Coast it varies from 10 miles in the vicinity of Palm Beach, Fla., to about 200 miles off Cape Cod, Mass. In general the 600-foot depth line is considered to be the edge of the shelf. From here the submerged land drops abruptly to ocean depths.

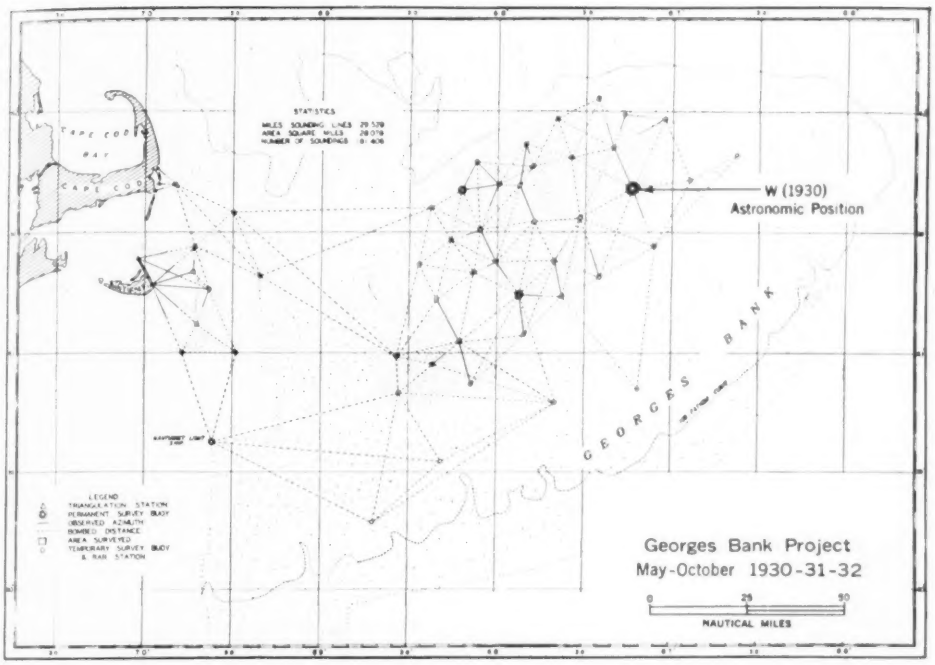
On September 28, 1945, a Presidential proclamation extended the jurisdiction and control of the United States over the natural resources of the subsoil and sea bed of the continental shelf. This added approximately 300,000 square statute miles to our jurisdiction in continental United States and about 550,000 square statute miles in Alaska.

Modern hydrographic surveys covering the area of the shelf have modified radically our former belief that the ocean floor is a flat, monotonous plain, devoid of rugged relief. How erroneous this concept was has been amply demonstrated by the many basins and ridges, troughs and peaks, that have been discovered since the advent of the new hydrographic methods. Submarine topograhy has been found in many areas comparable in extent and magnitude



TAUT-WIRE SUN-AZIMUTH TRAVERSE

IN SURVEYING OFFSHORE, DISTANCES BETWEEN CONTROL BUOYS ARE SOMETIMES MEASURED BY WIRE, AND BEARINGS ARE DETERMINED FROM OBSERVATIONS ON THE SUN.



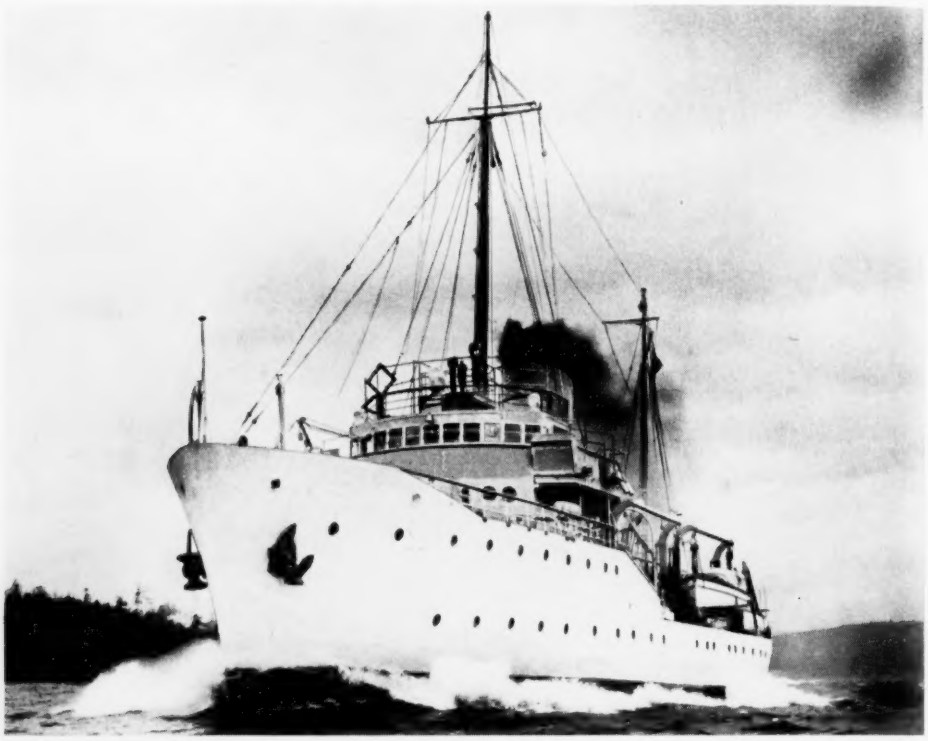
BUOY CONTROL SCHEME FOR SURVEY OF GEORGES BANK

A LONG SERIES OF STAR OBSERVATIONS FIXED THE POSITION OF BUOY "W" FROM WHICH THE CONTROL WAS EXPANDED TO A CONNECTION WITH SHORE STATIONS.

to some of the major topographic formations that exist on land. The continental shelf—particularly along the northeast Atlantic Coast—is indented by many submarine canyons, penetrating many miles into the shelf. One of the most pronounced of these, and perhaps one of the greatest in the world, is the one that, lying 120 miles southeast of New York Harbor, marks the submerged gorge of the ancient Hudson River. If this canyon could be stripped of its blanket of ocean, we could in some places see across it; the floor of the canyon would lie some 3,600 feet below. The mouth of this canyon has been traced to depths of 6,000 feet below sea level. The Hudson Canyon had been known to geologists for some years, but its true form and size were not known until modern methods of hydrographic surveying were used in 1936.

In the Gulf of Mexico, in the vicinity of the delta of the Mississippi River, a large depression, or submarine trough, has been found that penetrates the otherwise flat and smooth continental shelf for a distance of about 20 miles. To the northeast of this trough is a small dome-shaped hill which, geologists believe, is a salt-dome uplift. It stands about 160 feet above the sea floor and rises to within 200 feet of the water surface. In shape this dome has been found to resemble closely some of the buried salt domes along the coastal plains of Louisiana and Texas where many of our oil reserves are located. Numerous other, similar formations have been found along the edge of the shelf here, 100 and more miles from shore.

Off the coast of California, about 50 miles southwest of San Francisco, a huge submerged mountain has been found, rising 4,000–8,000 feet above the ocean bed and to within 2,500 feet of the sea surface. Other, similar seamounts, some more and some less pronounced, abound along the Pacific Coast and in the Gulf of Alaska.



U. S. COAST AND GEODETIC SURVEY SHIP *EXPLORER*

ONE OF THE LATEST ADDITIONS TO THE FLEET OF SURVEY VESSELS USED TO EXPLORE THE HIDDEN MYSTERIES OF THE DEEP, THE SHIP CONTAINS THE LATEST IN SURVEYING EQUIPMENT.

TIDE PREDICTING MACHINE

THIS ROBOT PREDICTS THE TIMES AND HEIGHTS OF THE TIDE FOR ANY TIME IN THE FUTURE.

An unusual and interesting submarine feature along the northern California coast is the Mendocino Escarpment, a clifflike formation, 6,000 feet high on the northern face, that juts into the Pacific for 66 miles, almost at right angles to the general trend of the coast line. This remarkable feature is on the seaward extension of the famous San Andreas Fault, which extends throughout the length of California. The San Francisco earthquake of 1906 was due to earth movement in the vicinity of this fault.

In the Gulf of Alaska, extending from Yakutat Bay and paralleling the Kenai and Alaska peninsulas and the Aleutian Archipelago, there is the remarkable Aleutian Trench. This elongated depression is traceable for a distance of 2,200 statute miles, the last 1,400 of which conform to the

arc of a circle of a radius of 760 statute miles. The floor of the Trench stands at its maximum about 25,000 feet below the surface of the sea and about 9,600 feet below the adjacent floor of the Pacific Ocean south of Attu Island. It was along the steep slopes of this Trench that seismograph records fixed the epicenter of the seaquake of April 1, 1946, which gave rise to such pronounced sea waves in the Hawaiian Islands and along the California coast.

In the Philippine Islands, just east of Mindanao, is the impressive Mindanao Deep, where the greatest known ocean depth—35,400 feet, or slightly over 6.5 miles—was obtained with an echo sounder. If we could put Mount Everest into this great ocean deep, the world's highest peak would still be covered by a mile of sea water.

Recently, electronic methods have been developed by the Coast and Geodetic Survey for use in hydrographic surveying. These will permit accurate surveys to be extended greater distances offshore than heretofore. Shoran equipment—a form of radar used during the war for precision bombing—has been adapted to, and successfully used for, position determination in the western Aleutians and off the coast of Maine. By this method a survey ship at distances of 50–100 miles offshore can be located with an accuracy comparable to that of a three-point visual fix on shore objects.

Another electronic device is being developed by which control of comparable accuracy with shoran will extend the offshore limit of accurate hydrographic surveys to as far as 300 miles. This may open up new fields for scientific research in an area that many believe to be a future reservoir of natural resources. Hitherto, one of the great drawbacks to such investigations has been the limitations in the methods of offshore surveying; even with the most nearly perfect geophysical methods there must still be a correlation with certain aspects of hydrographic surveying in order that a reliable topographic picture can be obtained of the area under investigation.

TIDAL PHENOMENA AND PREDICTION

Our country is coupled to the heavenly bodies in still another way. We are all familiar with the rhythmic rise and fall of the sea. This alternate elevation and depression—which at most places occurs daily and which we call the tide—can be expressed graphically in the form of a mathematical curve in which height and time are the two factors.

The Coast and Geodetic Survey is interested in tidal phenomena for two reasons. In its hydrographic work, the height of the tide must be known every instant during which a survey is in progress in order that depths obtained may be corrected and referred to a common datum plane for publication on the nautical chart. Tidal observations are also necessary in connection with the publication of tide tables, which furnish the navigator predicted times and heights of the tide at the important ports of the world.

The connection between the tide and the sun and moon was recognized at a very early period, but it was not until Sir Isaac Newton formulated his theory of the law of gravitation, during the seventeenth century, that a rational explanation of tidal phenomena was advanced. Newton proved that the tides were a necessary consequence of the law of gravitation; hence, the attractive forces of sun and moon on the earth and the waters overlying it are the principal tide-producing forces. The moon being nearer, its tide-producing force is more than twice that of the sun.

If we examine the tide curve for a period of a month, we find that the times of high

and low water of one day occur 50 minutes later than those of the preceding day. This period is characteristic of the tide practically everywhere and is irrespective of the range or type of tide found. The moon in its revolution around the earth shows the same retardation of 50 minutes.

The height of the tide during a month is affected by the relative positions of sun, moon, and earth. At times of new and full moon—when sun, moon, and earth are in line—the tides have their greatest rise and fall; whereas during first and third quarters, the rise and fall are at a minimum.

Tides differ in the character of the rise and fall. At New York, for example, there is the semidaily type of tide (two tides of approximately equal range); at Pensacola, there is the daily type (one tide a day); and at San Francisco there is the mixed type of tide (two tides with unequal range).

The tide varies in range from place to place. At the Atlantic entrance to the Panama Canal it is less than a foot in 6 hours, whereas at the Pacific entrance, only 30 miles away, it averages 12.5 feet. At Anchorage, Alaska, the rise and fall is approximately 33 feet.

Since the tide-generating forces are of astronomic origin, it might be supposed that the tide would exhibit similar characteristics everywhere. This would be the case if there were no other influences. Actually, the tides as they occur in nature are the result of the varying responses of the different ocean basins to the tide-producing forces, as modified by local terrestrial features. This theory of the tides that makes them local phenomena, rather than a single world phenomenon, was developed in the latter part of the nineteenth century by R. A. Harris, a tidal mathematician in the Coast and Geodetic Survey. In predicting tides for any port, it is necessary first to secure tidal observations for about a year. After that predictions can be made for any future time. Tide prediction is a complicated mathematical process, but the work has been greatly simplified by the use of the Tide Predicting Machine, designed in the Coast Survey. Astronomical equations involving as many as thirty-seven factors are solved mechanically, to produce the tide in nature.

THUS, we see that astronomy is at the foundation of all our survey operations: By means of triangulation we have tied together astronomic observations made throughout the country. This has made possible the determination of the figure of the earth and the best placement of our country on that figure. We have tied into the network of triangulation our mountains, rivers, coast lines, and other land features; and by extending our control network offshore we have tied in our waters, our continental shelves, and the ocean features beyond. In short, we have hitched our country to the stars.

PUTTING KNOWLEDGE TO WORK

By DONALD WASSON

After his graduation from Oberlin in 1935 Mr. Wasson attended the University of Genoa as an exchange student. In 1937 he received the degree of B.L.S. from Columbia University School of Library Service. In March 1941 he entered the Army as a private, emerging as a captain nearly five years later. He went immediately to his present post as Assistant Librarian, Council on Foreign Relations, New York City.

FOREIGN visitors to this country are often reported to be amazed by American facilities for research. It is gratifying that they should be so unconditionally enthusiastic about some of the institutions that most of us take for granted, but a librarian reading about their reactions wonders if they also have been shown the great wealth of library resources and facilities without which our research institutions could not function to maximum constructive capacity.

A visitor's possible lack of information would be excusable since, rich as we are in book resources and organized research collections, many of us accept our libraries as a matter of course; or we think only of the public or the university library. Comparatively few people realize that among the libraries of the United States there is a great class called "special libraries," the veritable heart of all research activity and research institutions. It is our purpose here to call attention to this group of libraries; to point out the major part they play in the modern research world; and to apprise the reader who normally depends on his library for recreational reading only—or at most for verification of simple facts such as weights, conversion factors, or figures on population—of the assistance special libraries can give.

Before describing some of the actual services and materials offered by these special collections, it may be well to define a special library and show how it differs from the general public or university library and how, at the same time, it supplements the activities and resources of both. The most satisfactory definition is that suggested by Linda H. Morley:

> A special library is a service organized to make available all experience and knowledge that will further the activities and common objectives of an organization or other restricted group, with a staff having adequate knowledge in the field of specialization and the activities of the clientele, as well as professional preparation. Its function is (1) to assemble information from published sources both within and without the library, (2) to secure information directly by correspondence and interview from individuals and organizations specializing in particular fields, and (3) to present this information at the appropriate time and place on the initiative of the library as well as upon request, that it may take an effective part in the work of the organization or group served.
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> Policies, methods, and collections vary, on the one hand according to the library's subject interests: economics or business, social sciences, sciences and technology, or the fine arts; and on the other hand, according to the type of organization of which the library is a part: a corporation, association, or institution, government office, or a general library having definitely decentralized departments.

From this it will be seen that, although special libraries are created to serve a particular clientele and are frequently separate entities, they are not divorced from other libraries. Their chief distinction lies in the fact that they devote themselves almost exclusively to one specialized field and one group of users.

Our definition calls the special library a *service*, and this is one of the most important points in the description. Created with the purpose of "putting knowledge to work"—the incisive slogan of the Special Libraries

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Association—these libraries, with their variety of resources, meet the demands of many types of people; and service is the underlying motivation of each of them.

No static thing, no mere depository of books and pamphlets, the special library is alive, and takes numerous interesting forms. It may consist of a few books, several periodicals, a few filing cases, and a well-trained librarian; or it may consist of several thousands of volumes, large collections of bound periodicals, a battery of filing cases, and a complete catalog, with a staff of several professional librarians, translators, and subject consultants. It may be organized as part of a larger library, with special rooms of its own; or it may occupy an entire building, complete with stacks and special reference and workrooms; or, as frequently happens, it may occupy a corner in a laboratory or business office. Whatever its size and however modest or impressive its quarters and appearance, its sole purpose is to serve the organization of which it is an integral part. Actual methods of service may vary, but the organization that wants facts and information rather than presumptions finds the well-organized library the most efficient research tool and the greatest economy in the time and effort spent on research functions. Not only is information readily available, but duplication of research efforts is precluded. Errors resulting in heavy loss of time can be avoided by having information available in libraries close at hand.

THE special librarian, aware of the activities of the organization the library serves, does not wait for readers to come to the library. On the contrary, by means of library bulletins and routing of periodicals and other materials, he takes the library to the rest of the organization and helps to keep the entire staff abreast of recent developments in relevant areas of interest. Products being developed (if the library is part of an industrial organization) or (in other types of organizations) the special research being done by an editor or a historian or a physician are of particular interest to the librarian, and he is guided by his knowledge of these activities in determining library needs and anticipating services. Being more than a mere library technician, he finds it necessary to acquaint himself as thoroughly as possible with the subject fields in which he is working and to be especially prepared to recognize information of immediate or potential value to his clientele. The special librarian realizes that his professional library-school training is only a beginning. Although he must be an efficient library specialist, familiar with library administration and technical procedures, he must go further and learn the methods, character, and present and future aims of his organization before he can be of full value. It is usually recognized that in-service activity, with participation in departmental meetings, planning groups, and discussions of policy, is necessary to complete his training and to enable him to function with maximum efficiency.

Books, periodicals, newspapers, pictures, and maps form the basic materials of most library collections, but these do not constitute the only sources of information in special libraries. As many media are to be found as there are means of transcribing thoughts and ideas. There are mimeographed and other processed reports, letter reports, circulars, dissertations and theses, trade catalogs, and many other apparently ephemeral forms that frequently contain unique documentary source material necessary for research in numerous fields. In addition, special libraries often include phonograph records, films, lantern slides, photographs, metal cuts, textiles, ceramics, herbarium specimens, and other material usually considered characteristic of museums. In discussing special libraries, much emphasis is always placed on their

function of providing current information. This is indeed one of their outstanding attributes, but it would be a serious error to conclude that they lack background or historical material. To say that they are of "limited use to the scholar," as one university librarian did some time ago (SM, June 1946, p. 515), is misleading and does a disservice to the scholar. Any librarian is witness to the fact that there is a wealth of source material in these special collections that no serious student can afford to ignore.

Acquisition policies and the collection programs of special libraries in the same fields often differ. Some libraries concentrate on providing only the most up-to-date material; some collect mainly historical data; and some, probably the majority, attempt to include both current and historically important background material. Methods and policies of acquisition are always based on the work of the organization, and form the No. 1 administrative problem of the library.

Sources of acquisition are many and often complicated. They must be completely familiar to the librarian. Standard trade bibliographies, book-review sections of newspapers and general literary magazines, and national bibliographies of the United States and other countries are consulted as a matter of course, but there are many other, less obvious sources. The subject periodicals for each field are sources to be checked; the lists of documents published by our Federal, state, and municipal governments, as well as those published by foreign governments; rare bookdealers' catalogs; subject acquisitions lists published by other libraries; publications of professional organizations, such as the *Technical Book Review Index*, published by the Special Libraries Association, and those of research organizations—all must be familiar to the special librarian and be studied regularly. These sources differ in each field, but the librarian often finds it necessary or profitable to search the special publications of other fields for related materials. After studying all available sources, discrimination in selection must be exercised. The collections of librarians specializing in current or ephemeral types of literature frequently change in emphasis as fields of knowledge expand, and often disclose the latest developments and directions of expansion in the subject fields of interest. It is no exaggeration to say that many alert librarians lead the way in dictating new fields of research, because, in their association with other librarians and their frequent literature search, they turn up references the research staff has not had the opportunity to find.

Much ingenuity has been shown in the arrangement of special library collections. This is an important point because, if the library material is not arranged logically and conveniently, it loses much of its value. Classification and cataloging schemes are always selected according to the type of collection and the use to be made of it. These are often the standard systems used in general libraries, but revised or expanded to suit the collection at hand. The familiar dictionary catalog that includes author, subject, and title cards in one alphabet may be abandoned in favor of either a subject catalog, with a separate author catalog, or a classified decimal system catalog such as that in use in the Engineering Societies Library in New York. Sections of the Dewey Decimal Classification may be expanded to take care of large collections on international law, aeronautics, and other subjects; or a standard classification scheme may be given an entirely new interpretation. Subject headings for the catalog (the words used to describe the contents of books) are devised especially to cover the collections in individual libraries and may be completely new, or they may supplement those in standard lists such as the Library of Congress subject headings list.

Care is constantly exercised to keep these headings up to date and to provide for the correlation of old headings to new or related ones. Special indexes and catalogs sometimes supplement standard systems, bringing to light materials buried in one classification under different headings, and relating subjects to one another in such a way as to make them more readily usable. This function of special, tailor-made arrangements cannot be overemphasized, since it forms the basis of value of many collections that might otherwise be of no more importance than any other collection in the same field.

The special librarian does not limit himself to the resources of his own collections in providing library service. Cooperation with other special libraries provides materials through interlibrary loan, in which case volumes may be borrowed from other organizations; or, if this is not possible or practical, photostatic and microfilm copies of required material may be secured. Frequently, extensive information is secured by correspondence. Special libraries have been most active in supporting schemes for interlibrary cooperation and have contributed fully to union lists of serials, regional catalogs of books, descriptive manuals of resources, and other projects that underlie such cooperation. Working along with the large general library, the special library often supplies advance information of a highly specialized nature, which the former is not expected or designed to provide; in a reverse manner, the special library often depends upon the large public library for long runs of periodicals and historical works, which it would be impossible or impractical for the smaller library to acquire and store because of cost and lack of space.

In the special library much time is spent on such activities as compiling bibliographies, searching out source materials, preparing abstracts of books and periodicals, making patent searches, translating foreign publications, and indexing special materials. Thus the researcher and busy executive is saved time and is frequently made aware of information he did not know existed.

One of the best means of understanding the extent of special libraries, the fields covered by them, and the services they offer is to examine *Special Library Resources*, a publication recently issued by the Special Libraries Association. More than 2,400 special libraries in this country and Canada are listed in four volumes.

The general arrangement of information is alphabetical by state, and then by city and name of organization within each state. Each entry includes the name of the organization and its library, its address, the names of the librarian and of the person to whom he is responsible, the number of persons on the staff, the specialists and translators available, and the personnel served. There are special libraries located in almost all types of communities, from villages to the largest cities. Staffs range from one trained librarian to fifty or more; the clientele served may be restricted to the organization alone, or it may be joined by members of the community. In noting the services of available specialists, not only are those regularly employed in the library included, but any available elsewhere in the particular organization or vicinity. Interlibrary loan privileges, whether limited or liberal, are stated, with information on reproduction equipment such as photostat or microfilm.

Descriptions of the collections in these libraries include the subject fields covered and often are given in considerable detail. Their resources are divided into the following classifications: books, periodicals, and the disposition made of them; newspapers; pamphlets; and the number of vertical file drawers. Significant and uncommon holdings are indicated by title, and unusual

collections are described. Union lists such as the familiar *Union List of Serials* are noted when the library has reported its holdings.

Periodicals or serials not included in any existing union list are noted, as are special subscription indexes and abstract services received, such as *Science Abstracts*, *Ceramic Abstracts*, *Engineering Index*, and *Public Affairs Information Service*. Many of the libraries described maintain special indexing and abstracting services that are unique, and these also are listed. Interesting examples, typical of the service offered by special libraries, are the bibliography on physical oceanography in process at the Scripps Institution of Oceanography, the index of periodicals relating to lumber reported by the library of the National Lumber Manufacturers Association, and the index of literature on stainless steel in the library of the Rustless Iron and Steel Corporation.

ORGANIZED in 1909, the Special Libraries Association is the national professional group to which special librarians belong. It is dedicated to the promotion of high professional standards for libraries and library personnel and functions as a clearinghouse of information for its members and persons interested in organizing new libraries. *Special Library Resources* and the *Technical Book Review Index* are only two of many valuable reference tools sponsored by this association; they do, however, typify the work of the organization in this field. Over 4,800 members are organized into subject groups as follows: Advertising, Biological Sciences, Business, Financial, Geography and Map, Hospital and Nursing, Insurance, Museum, Newspaper, Religious, Science-Technology (with Chemical and Public Utilities Sections), Social Sciences, Transportation, and University and College. In addition, chapters composed of the same subject groups are located in the main centers of population across the country. This geographical distribution permits frequent meetings throughout the year and facilitates local and regional cooperative projects.

The unique functions of the special libraries were high-lighted by John A. Lapp, a pioneer in the field, when he said:

> It may be said that wherever there is a problem of government, of business, of finance, of manufacturing, of commerce, there the idea of knowing all there is to know about the problem must certainly prevail in the hands of men who think and who act upon information, rather than upon the rule of thumb. The extension of this idea (by means of the special library) means that the great storehouses of knowledge which have been created throughout the ages and which are being added to daily by research and investigation shall find a means of making the knowledge which they possess articulate in everyday affairs. Instead of being hidden in the resources of the general library, or instead of being scattered and uncollected, it will be focussed upon the jobs which men perform and will help in the solution of problems which come. . . . Enough knowledge is stored up to solve a great many of the problems of the day if channels were open between the storehouses of information, the executives who control policies and the men who carry them out.

In those few words, then, lies the meaning of special libraries.

AN INDUSTRIAL RESEARCH LIBRARY

By LUCY O. LEWTON

Miss Lewton (M.A., Columbia) has been in industrial research laboratories in various capacities since 1922. She is the author of two U. S. patents, one of which is "A Process for Removing Harsh Constituents from Tobacco." During the war she was Chairman of the Cooperative Abstracting Group on Conservation and Substitution of Strategic Materials for the WPB. At present Research Librarian at the Central Research Laboratories of the Celanese Corporation of America in Summit, N. J., she is also Chairman of the Science-Technology Group of the Special Libraries Association.

IT IS a long way from the medieval "Alchymyst" working alone in a dark, cluttered cell among his alembics and brick furnaces, as pictured in the Teniers paintings, to the groups of modern investigators in an air-conditioned research laboratory, yet it is significant that the large tomes and parchments of "recipes" consulted by the alchemist have retained their importance to research under the more modern guise of special science libraries. Systematic techniques of literature research as a forerunner of actual laboratory work have become the modern counterpart of the random poring over manuscripts that accompanied the alchemist's hit-or-miss search for the philosophers' stone. For, just as the distillation column has replaced the alembic and the electric oven the brick furnace, so the cryptic recipes of the alchemist as a means of recording results of scientific research have been superseded by detailed monographs, communications to scientific journals, articles in trade and professional journals, patent specifications, and unpublished company research reports.

This ever-mounting flood of recorded results of the world's scientific investigations, evidenced by the fact that 30,523 articles were indexed by *Chemical Abstracts* in 1943 as against 19,507 in 1923, has demanded that specialized subject collections be formed and special systems developed for evaluating, classifying, digesting, and storing these observations lest they become lost as a maze of isolated and, what is worse, unapplied facts.

Particularly is it important in the concerted attack now being made on the secrets of nature, in which all the sciences are marshaled (as exemplified by the cooperative programs on nuclear fission to be carried out at Brookhaven and Argonne National Laboratories), that no grain in that vast storehouse of tested facts be lost.

The amount of money spent on "pure" research by government, universities, and industry in 1947 is estimated at 335 million dollars, or five times that spent ten years ago. Industry alone invested 75 million dollars in research during the war, and about 2 percent of annual gross profits is invested by manufacturers in research. Yet the line between pure, or theoretical, and applied research is not so sharply drawn as formerly: much so-called pure research carried on at universities today is done to build a foundation for the new industries of tomorrow; and the list of corporations expanding their research activities or building laboratory centers this year reads like a "Who's Who of American Industry."

All this intensification and expansion of scientific research has had a concomitant effect on the development of scientific libraries. The membership of the Science-Technology Group of the Special Libraries Association has risen to 2,000 persons, employed in 950 different scientific libraries, of which about 350 are industrial research

libraries. Many of these are in connection with the laboratory research centers of the respective companies. Staffed with technically trained librarians, these company libraries have extensive specialized subject collections that it would be hard to duplicate elsewhere. They are, in fact, reference authorities in the fields in which the laboratories or the company operate and have conveniently collected and suitably classified in one place material which, in an institutional or public science library, is scattered over many locations and topics.

Since we have a competitive economy, industrial research must keep in touch with the progress of its contemporaries, as well as build up that body of best-ways-of-doing-things that is technological "know-how." The industrial research library, therefore, becomes not only the first point of attack on a problem, but also a repository of the company's technical experience as reflected in its own research reports and unpublished technical data, eliminating duplication in further investigations.

A science library differs from special libraries in other fields not only in its sources and subject matter, but in the characteristic importance of patent literature and the well-developed abstract journals.

Since in industry time is of the essence and a more select clientele is served, the science library must be less according to Hoyle than the straight library; it must be more specialized, with short cuts and with a technique more intelligible to the busy scientist-user; it must also allow for a detailed knowledge of the subject matter on his part. For example, contents of books must be more carefully evaluated, and special detailed treatment of a given phase of a subject noted. Often it is important to know, for instance, that of all books on fractional distillation only one certain text mentions the effect of the number of plates on the efficiency of a column; or that one text describes aldehyde resins in detail, whereas others have but a passing mention of them.

Subject headings or cross references must be more extensive, up to date, and in the nomenclature actually used in that technology and industry. Dictionary-type, significant-word indexing often is impossible to use, for an article under "Anodic cleaning" would be separated from "Electropolishing," although both are the same technique. Owing to the rapid strides in technology, the subject catalogs of an industrial research library need constant revision, because subjects that yesterday were merely obscure aspects of some industrial method, today may be the centers of special industries and be acquiring a patent literature of their own.

Although admittedly texts form only a minor part of a special library, in a science library they serve as convenient summaries of accepted practice, used more for general orientation than as sources for literature research. Book selection in an industrial science library, therefore, must be a censored activity, exercised with more judgment, perhaps, than in the case of libraries where completeness of bibliographic collections is sought. Periodical literature as a source of new developments supplies more up-to-date information, much of which never appears in books in so detailed a form. This original literature is also better indexed in the abstract journals such as *Chemical Abstracts*, *British Abstracts*, and *Science Abstracts*, which are the basic search tools of a science library. The journals in the different and now-overlapping branches of the sciences, numbering 4,318 of chemical interest alone, form too large a body of printed material for even the most generously endowed industrial research library to own.

Often the most valuable sources in an in-

dustrial research library are neither texts nor long sets of bound periodicals, but special collections of patent specifications, pamphlets, trade literature, and the subject catalog of abstracts from current literature, all expertly indexed from the particular viewpoint of the problems being investigated or the interests of the company. Such files, supplemented by the unpublished research and progress reports of the company's investigators, can be the heart of an industrial research library, whose quality and value can hardly be measured by the size of its shelf possessions or the number of its books, but rather by the speed with which pertinent information is produced upon request.

The industrial research library differs likewise from other types of science libraries in the kind of service needed and expected. Whereas the large repository library may be consulted by the scholar who wishes to pursue his detailed studies on possibly but a single topic, the industrial research library is apt to be consulted by the salesman, the production man, and the financial executive, as well as by the scientific investigator. It is expected to be not only up to date in its collections but also, keeping pace with the changing program of research in the laboratories, to be able to offer on the spot at least some background information on the greatest variety of scientific topics. For the investigator, such a library makes long-term literature and patent searches, culminating in the literature-survey report that precedes work on a new project. Such a survey may analyze the factors involved in a problem, give types of technique and apparatus to be employed, and open up a whole vista of as yet unexplored avenues, since its object is to make known what has been done before.

Keeping abreast of new developments as mirrored in the trade and technical magazines, not only for the sake of maintaining resources and information, but also for the purpose of calling the attention of the investigator to an item that can guide or stimulate him in his research, involves a constant review of magazines and patents and the issuance of abstracts in the form of a periodic library bulletin. Such a publication, if it includes news of trends in the industry, adds to the general industrial education of the whole scientific staff.

Most of all, the day-to-day furnishing of isolated information, called reference work, is the chief product of the industrial science library. The kind of questions asked may vary from the current price of a raw material or a chemical of commerce to methods of determining viscosity of synthetic latexes, which involves searches in German technical reports on microfilms. The library's answers to such questions not only expedite research but may actually stimulate discovery and invention. Stories of actual discovery made through library research, table talk whenever a group of technical librarians get together, show that even "geological reconnaissance" can be done in the library.

Obviously, these functions require mental agility, for the technical librarian in industry is not merely the curator of a collection, but an actual researcher whose tools are the materials in the collection. Preeminently, this type of librarian must, like the research scientist, be a subject specialist, in order that he may properly interpret a request and correlate the information he finds; moreover, he must be well oriented in all the basic sciences and conversant with the practices and the state of the art in the particular industry. He must know at least three modern languages and be aware of the accepted terminology of the several sciences. Finally, the library researcher must be cognizant of patent procedures, the economics of research, and marketing, or end uses of the products of research.

Library research, as exacting and as painstaking, and offering as much opportunity

for creative ability as laboratory research, is attracting both men and women who, besides a broad training in the sciences, have a literary bent, an eye for the historical aspects of science, and are possessed of the administrative ability to plan and lay out the many orderly routines of a library.

A CLOSE-UP of the functioning of an industrial research library is possibly best obtained from a consideration of an individual library. Among the important industrial research libraries is the Central Library of the Celanese Corporation of America, recently established at the Research Laboratories of the corporation in Summit, N. J. It covers the fields of textile and plastics technology and cellulose chemistry; serves about 150 chemists, physicists, researchers, and development engineers. It has a staff of three clerical and three technically trained personnel. This library represents the merger of two sources of technical information previously existing within the company. One was the Library and Data Files of the old and well-known Celluloid Company, of Newark, N. J., which ultimately became the plastics subsidiary of the Celanese Corporation. Organized for the purpose of supplying the literature and patent information for the Development and Research Department of this subsidiary, this library had built up extensive files on the history, fabrication, and uses of the cellulosic plastics, and on plasticizers and organic chemicals; it also had a complete collection of patent literature on these and related subjects. The other library was that of the Amcelle Research Department at the Cumberland, Md., cellulose acetate textiles subsidiary. It had extensive book and bound-periodicals holdings, dealing chiefly with textile chemistry, dyeing, physical testing, and allied topics.

When, in 1944, it was decided to centralize the research activities of all branches of the company at the new laboratories at Summit, plans were made to centralize the research library also. Accordingly, the list of books and bound-magazine set holdings of both libraries was evaluated, first, by the scientific staff that was to be transferred to Summit; second, by the chief of the Patent and Data Division, under which the new library was to operate; and, finally, by the Research Librarian. In this way a collection of about 1,000 book titles, 117 magazine subscriptions, and 108 sets of bound journals was put together. The book collection was then entirely reclassified, using a simplification and modification of the Dewey Decimal System, with considerable expansion in the classes of organic chemistry, textiles and plastics, and elastomers.

The special files consist of general data material (photostats, clippings, pamphlets, and reprints), equipment and materials catalogs (including trade literature of other plastics manufacturers), and patent specifications. This material is considered published data, is indexed with an abstract on 4″ x 6″ cards, and filed by a classified subject heading scheme, with individual subjects assigned numbers under which the original material is filed. It is available to all users of the library. Experiments are being carried on in the use of punched cards for indexing this material.

Supplementing these special files, and considered an important source of information, are the research report files of the company kept in the Data Department. As much of this is unpublished material, it is very carefully indexed by subject.

The Central Library compiles major bibliographies; makes translations and patent searches, working in close collaboration with the chemist in charge of patent work; and answers approximately 15 requests for spot information per day. Its routine, aside from ordering all printed matter for laboratory researchers and the circulation of current magazines to them, includes the review of

about 75 journals, abstracting from these significant items of interest for its abstract subject file and for the attention of individual investigators. The publication of a library bulletin of abstracts is at present under consideration. The *Patent Gazette* is reviewed, and specifications ordered by the Patent Chemist are carefully indexed by subject, number, and assignee.

Among administrative duties, the Central Library is charged with classifying all books received in the company. A Union Catalog of such books, giving their "branch" location is maintained by author and subject in the Central Library at Summit.

Other libraries of the company are located at the Newark, N. J., Plastics Development Division; at the Amcelle, Md., Textile Development Division; and at the Rome, Ga., Viscose Plant. A library has recently been organized for the executive office in New York City to deal with the economics and management aspects of the textile industry; and a library on petroleum chemistry and technology is being assembled for the Petroleum Research Laboratory of the company in Clarkwood, Texas. It is hoped to weld these into a system of libraries, each becoming reference specialists to serve all the branches of the company with the information that each library is best suited to produce. Thus, in this one large industrial company the various units of technical information are being coordinated with its centralized scientific activities.

As Arthur D. Little, head of one of the largest industrial laboratories, once said: "Since it is the function of the laboratory to extend our knowledge, it cannot function properly unless its working units are strengthened and refreshed and stimulated by the constant stream of facts, theories and opinions which it is the purpose of the library to supply."

YE SHALL KNOW THEM BY THEIR FRUITS

The faith of old bestowed on God
Is due to Science, some impute.
To Science this seems very odd,
But Time *with logic absolute*
Declaims no man can understand
What Einstein proved with figures queer,
That we must take our faith in hand
And blindly follow this great seer.

Saint Matthew said fruitions prove
The prophets true or else deficient.
The blast which makes a tyrant move
To end his war is proof sufficient
That product of the square of C
And M *will make a lot of* E.

PAUL D. HARWOOD

THE AIR UNIVERSITY LIBRARY

By WAYNE S. YENAWINE

A graduate of the University of Illinois Library School in 1934, Mr. Yenawine (M.A., Illinois, 1938) has been associated with university libraries ever since. He was a logical choice, therefore, for the post of Director of Libraries at the Air University, Maxwell Field, Ala., where he has been since May 1946.

GENERAL CARL SPAATZ, in speaking to a group of California educators, said,

> We in the Air Force have realized that our own education must be geared to a global concept of war and peace. It is not enough for air men to be technicians. They must be versed in human affairs; they must be educated up to the standard required by the history-changing role of air power.

To implement these educational objectives, Air University was activated March 15, 1946, and its first classes started on September 3, 1946. The component schools and colleges of the university include the Air Tactical School, the Air Command and Staff School, the Air War College, The Special Staff School, and the School of Aviation Medicine. The university is responsible for the selection and progress of officers enrolled in civilian universities, for the preparation and review of extension courses, for training and supervision of AAF instructors at non-AAF schools, for supervision over the curriculum of the Army Air Forces Institute of Technology, Dayton, Ohio, and for research in the employment of air power. The Air University thus integrates the educational functions of the AAF into a system of higher education.

Conscious of changing concepts and keenly aware of changing requirements of officer personnel, the Air Force created Air University to provide its officers with a broad, comprehensive education. This education is conceived as a continuing process, beginning soon after the completion of the officer's flight training and extending over a twenty-year period in his career. The levels of instruction are higher than ever before attempted by the AAF, and they correspond to postgraduate education in civilian universities. Emphasis is twofold: first to furnish officers with factual knowledge, skills, and techniques; second, to develop the officer's ability to think clearly, accurately, and objectively about the future doctrine, tactics, and strategy of air power.

Establishing a new university meant establishing a new library. The accelerated development of a research library simultaneously with organization of the faculty, staff, curriculum, education policy, plant facilities, etc. revealed the vision and tenacity of the Commanding General, Muir S. Fairchild. Materials, personnel, equipment, and building for the library shared top priority among the multitudinous problems that faced the small group of officers who had abruptly turned from combat to higher education. The first decisive steps included the requisition and removal to Maxwell Field of a collection of 10,000 volumes, 25,000 military documents, and several thousand maps that had supported the AAF School of Applied Tactics, then recently inactivated. A Director of Libraries was selected and appointed. Standard library equipment was requisitioned; some was shipped to Maxwell Field from inactivated AAF base technical libraries. A strategically located one-story building was selected, and its 14,000 square feet of floor area remodeled into a functional library building. These steps were accomplished in three incredibly short months in the spring of 1946.

The Air University Library capitalized on

the momentum of its running start and during the first year realized professional potentialities considerably beyond expectation. To printed resources have been added 22,000 volumes of books and bound periodicals; 50,000 restricted military documents; 75,000 maps and charts; a special reference library of 20,000 documents on the arctic, desert, and tropic regions; the Layne Library, containing 3,800 documents on military intelligence; the Hardwick collection of Air Staff intelligence requirements of the Far East; and a collection of approximately 100,000 archival documents pertaining to the history of Air Force operations. To the personnel resources have been added twenty-five professional, sixteen subprofessional, and four clerical staff members. A complete microphotographic laboratory has been added to the library's equipment. Library activities expanded into two additional buildings at Maxwell Field, and during the first year two branch reference libraries were established: one for the Air Tactical School at Tyndall Field, Panama City, Fla.; and the other for the Special Staff School at Craig Field, Selma, Ala.

These tangible developments of the library are obvious and essential to the educational mission of Air University. More fundamental considerations, however, are the extent to which these resources contribute to that educational mission and whether they contribute lasting benefits to the officers for whom they are intended. In this connection, the library was planned as a resource laboratory where officers will be stimulated to reach new horizons in their thinking and where they can explore the past in printed record under favorable conditions. The concept of a resource laboratory assumes a close relationship between instructors and resource use, and conditions are basically more favorable at Air University than at many civilian universities.

The instructors, all Air Force officers, were hand-picked because of their brilliant operational records and because of their outstanding capacity for dynamic leadership. As a group they are young, enthusiastic, and receptive to the program of Air University. What they lack in teaching experience is balanced by a freedom from pedagogical dogma and an eagerness to learn the techniques of managing seminars, supervising theses, developing student ability for critical thinking, evaluating resources, etc. The instructors have found the Air University Library a new experience in their careers and are intent upon learning the mysteries of card catalogs and classification schemes, their responsibilities as book selectors, their obligations to the student in bridging the gap between class discussion and resource use, and similar duties of a faculty, which librarians generally take for granted.

The instructors' lack of experience in teaching and in using university library facilities explains some of the unique features in the library's organization. Since the faculty is in the process of being indoctrinated, they are not ready to exert any appreciable influence in book selection. Those whose military careers began just prior to or during World War II found support for their combat assignments primarily in military source materials. In contrast they are realizing that the resources needed to support their teaching assignments in such fields as logistics, air intelligence, and strategic use of new weapons cut across many subject fields and embrace a wide variety of published forms. Until such time as Air University can develop a corps of great teachers for the Air Force, the library will assume the major responsibility for developing adequate materials resources.

Professional personnel for the library division were selected so as to provide within the staff a variety of subject specializations. Through a division of responsi-

bility among individual staff members, emphasis has been given to all pertinent subject fields. Very little emphasis has been given to contemporary national literatures since the literary product of the world is significant to local needs only as it reveals objectives of foreign propaganda. During the first year 15,000 volumes (books, reference sets, files of periodicals, and serial publications) were selected by the library staff and purchased by the Acquisition Department with a $70,600 appropriation from the AAF library book fund.

The acquisition problem in the Air University Library involves military documents as well as commercially published materials. The military documents, classified for security reasons as *restricted*, *confidential*, *secret*, and *top-secret*, are difficult to locate and obtain since there are no bibliographic summaries comparable to the *Cumulative Book Index*, and since the importance of many documents to national security tends to limit distribution and discourage dissemination of information about them. When Air University needs military documents, the library, in most cases, must exert its initiative to verify their existence, locate copies, and expedite acquisition through its own resourcefulness. The Collection and Analysis Section, composed exclusively of military personnel, was provided to define the university's requirements of military documents based upon an analysis of the curriculum and upon available resources, and to select, locate, and obtain the documents needed for instruction and research. The familiarity of the faculty with military documents has enabled instructors to render invaluable assistance in this activity.

Just as book selection has been a major responsibility of the library, so also have been the evaluation of materials, guidance in using bibliographic techniques, and instruction in methods of documentary or historical research. The Air War College and the Air Command and Staff School ask each student officer to prepare a thesis as a requirement for graduation. Most of the students have not had appropriate experience as background for such an assignment, and few of the instructors are prepared at this stage of the university's development to offer the students more than a critical appraisal of the doctrine, concept, or proposal contained in the finished thesis. From a realization of this situation grew the need for a Reference Department experienced in working with graduate students, and for the special staff of the Documentary Research Section, composed of productive scholars who have held research professorships in civilian universities. The staff of the Documentary Research Section works constantly with the research resources of the library and is developing specializations in areas of literature covering the Use of Air Power in the Polar Regions, Mobilization of Economic and Political Resources in Support of Air Power, Air Defense of the United States, Technological Research and Development, and Air Intelligence. Members of the library staff enjoy a close relationship with student officers and have opportunities in student guidance generally performed by the professor in civilian institutions. The experience has been stimulating to the staff and helpful to the students.

Resources in the library are made as accessible to the user as possible consistent with security regulations. Materials with a security classification are located in a restricted area and serviced by the reference librarians. All other materials are immediately accessible to the user, and orientation is provided to increase the user's resourcefulness in the library. The faculty receives information about the library in an in-service instructor-training course, and specific information is given each member in an *Instructor's Handbook*. At the time assignments requiring use of the library are given,

students attend lectures given by the staff on documentary research techniques, thesis writing, and use of the library. The lectures are followed by a tour of the library, and each student is given a *Library Handbook*. More effective than any other agency, however, is the personal instruction given users of the library in connection with their need for the selection of subject materials, evaluation of sources, or location of data. The purposes of library instruction are to lead, direct, and train the reader to use the Air University Library effectively and to develop a learning process that will carry over beyond his formal education.

It is significant that the Air Force wants well-informed, widely read officers who are capable of using air power to preserve the peace. The library faces the challenging task of influencing the self-education of officers throughout the Air Force by stimulating more independent reading and by raising the general level of reading. The logical starting point in this activity is with Air University students. The library has assisted instructors in selecting not only assigned reading but collateral reading as well. The instructors encourage discussion in the class and seminar about current controversial issues of national or world importance and about current publications. These discussions have been coordinated with the library, and the staff has sustained some of the student interest through the display or suggestion of pertinent materials. A permanent display in the library contains recommendations for an officer's private library, and an annotated bibliography is available for distribution to all students and visiting officers. A reading list has been prepared for independent reading, and the titles included are grouped according to the reading interests of junior, staff, and command officers. This list was mailed to all Air Force officers on active duty, with the suggestion that selected reading be accomplished in preparation for future enrollment in Air University.

These are only a few of the activities and problems of the Air University Library. The establishment of a new research library creates some problems the older libraries were spared, but it also creates new opportunities that the older libraries are denied. As the library program for Air University evolves the record will show how well those opportunities have been used.

THE GEOLOGY OF SHAKESPEARE

By BRADFORD WILLARD

Dr. Willard (Ph.D., Harvard, 1923) has been head of the Department of Geology at Lehigh University since 1939. In pursuit of his vocation he has published more than one hundred articles on geology, chiefly on the Paleozoic stratigraphy of the Northern Appalachians, particularly the Devonian of Pennsylvania. He devotes his spare time to Shakespeare.

TO William Shakespeare has been attributed the gift of omniscience. From his writings one may select passages that to modern eyes appear to support this attribution. That he could not possibly have had any knowledge of geology as we today understand it is axiomatic. The science was not even named until about the mid-eighteenth century. Still, just as one might quote from Shakespeare's writings passages on biology, mathematics, and other branches of human knowledge, so one cannot deny that his plays and poems contain many references to geologic phenomena and to objects of geologic significance. Has he ever been given credit for occasionally sounding a geologic note? Being myself a Shakespeare addict by avocation and a geologist by vocation, it is inevitable that I have noticed passages such as "the flinty ribs of this hard world" (*Richard II*, V, 5, 20–21). I have brought together my findings, but I make no claim that Shakespeare was a geologist or had any special insight into earth science. How many of the passages I have culled are the consequences of his own observations, how many he acquired through hearsay, or how many may have been lifted from extant written accounts, I shall not attempt to differentiate. By no means do I presume to have unearthed every possible citation; much less shall I quote all those that I have found; still less can I attempt to cover every ramification of geology upon which Shakespeare's works touch. What I wish to emphasize is that his writings indicate what was commonly known by Elizabethans of the fundamentals of geology.

Ever since some early forebear of ours discovered that of all stones, flint made the best weapons and tools, man has exploited flint. With that exploitation, geology had perchance its first application to the needs of primitive man. Early civilizations recognized geologic phenomena. From Isaiah's preaching, "Every valley shall be exalted, and every mountain and hill shall be made low: and the crooked shall be made straight, and the rough places plain," one must infer inklings of physiographic processes. How far more realistic are his lines than Jacob's misconception of the "everlasting hills." Greek and Roman thinkers added their bits to geology. The unlearned peasant has long had his rule-of-thumb weather proverbs, has known something of the occurrences, uses, and values of rocks and minerals, the ways of flowing streams, the significance of springs of water, the characteristics of mountains, and the disasters of the earthquake and the volcanic outburst. Early mariners contributed the germ of oceanography. In 1546 Georg Bauer ("Agricola") summarized in *De re metallica* most of what was then known of mining. There is considerable geology in this classic, but, if Shakespeare ever saw a copy, he was not so impressed that he let it influence his writings.

In drawing upon Shakespeare for allusions to geology, I have confined my choice to the more earthy branches: physiography, lithology, mineralogy. Some passages found are farfetched, and some allusions or connotations if quoted would entail long explanations. I have passed most of these by and present only the more obvious. Though

I omit most citations on meteorology and climate, there are many passages on storms, frost, snow, hail, rain, dew, thunder and clouds, wind and calm, climate and the seasons. I cite only those vivid St. Elmo's fire lines from *The Tempest* (I, 2, 196–206):

I boarded the king's ship; now in the beak,
Now in the waist, the deck, in every cabin,
I flamed amazement: sometimes I'ld divide,
And burn in many places; on the topmast,
The yards and bowsprit, would I flame distinctly,
Then meet and join. Jove's lightnings, the precursors
O' the dreadful thunder-claps, more momentary
And sight-outrunning were not: the fire and cracks
Of sulphurous roaring the most mighty Neptune
Seem to besiege, and make the bold waves tremble,
Yea, his dread trident shake.

Shakespeare's works include frequent references to seismic disturbances. The trembling land finds passing recognition in *All's Well That Ends Well* (I, 3, 91–92); *As You Like It* (III, 2, 195–196); *Henry V* (II, 4, 100); *Henry IV*, Part I (III, 1, 16–17); *King John* (V, 2, 42); *Much Ado About Nothing* (I, 1, 275); *Pericles* (III, 2, 15); *Romeo and Juliet* (I, 3, 23); *The Tempest* (II, 1, 315); *Venus and Adonis* (line 648). A passage from *Henry IV*, Part I (III, 1, 28–33), is interesting as it reflects the lingering influence of the Roman Lucretius (*circa* 50 B.C.), who, with others of his time, attributed seismic disturbances to winds in subterranean vaults:

oft the teeming earth
Is with a kind of colic pinch'd and vex'd
By the imprisoning of unruly wind
Within her womb; which, for enlarging striving
Shakes the old beldame earth and topples down
Steeples and moss-grown towers.

In contrast to earthquakes, volcanism is given short shrift with such brief citations as those to Mount Aetna in *The Merry Wives of Windsor* (III, 5, 128) and *Titus Andronicus* (III, 1, 242). Perhaps the difference in emphasis reflects personal experience. Shakespeare himself probably witnessed, or at least talked with witnesses of, English earthquakes, which, though unknown of the first magnitude, can be impressive. On the other hand, he probably never experienced the terrors of an active volcano.

Minerals, jewels, precious stones, gems, and rocks all have places of honor in Shakespeare's writings. Omitting such stereotyped comparisons as eyes to diamonds and lips to rubies, there are plenty of references to jewels and gems. That something of their true as well as fancied or supernatural attributes, baneful or beneficial, was understood is demonstrated by lines 211–217 of *A Lover's Complaint:*

The diamond, why 'twas beautiful and hard,
Whereto his invised properties did trend;
The deep-green emerald, in whose fresh regard
Weak sights their sickly radiance do amend;
The heaven-hued sapphire and the opal blend
With objects manifold; each several stone
With wit well blazon'd, smiled or made some moan.

The old idea of fabulously rich deposits of precious stones in the ocean's deeps is evinced in such a phrase as "the sea's rich gems" (Sonnet XXI, line 6), and implied in *The Tempest* (I, 2, 396–398):

Full fathom five thy father lies;
Of his bones are coral made
Those are pearls that were his eyes.*

Although the word "adamant" recurs somewhat often, it may not invariably refer to the diamond, because adamant was also used for the lodestone, as implied in "You draw me, you hard-hearted adamant," from *Midsummer Night's Dream* (II, 1, 195). Agate is mentioned in *Henry IV*, Part II (I, 2, 18–20), and Shylock (*Merchant of Venice*, III, 1, 125–126) bemoans the loss of his turquoise. Of nonprecious minerals, the list is only fairly impressive. Jet is

* Cf. the lines from Gray:

Full many-a gem of purest ray serene
The dark, unfathomed caves of ocean bear.

cited in *Henry VI*, Part II (II, 1, 112). From *As You Like It* (I, 3, 114) comes "of umber smirch my face." Sulphur finds a place in *Coriolanus* (V, 3, 152) and in *Cymbeline* (V, 5, 240). "Burn like the mines of sulphur" is quoted from *Othello* (III, 3, 329). Amber, by some purists not conceded to be a mineral, *sensu stricto*, yet surely of geologic interest, appears in *Hamlet* (II, 2, 200–201) and in *Love's Labor's Lost* (IV, 3, 87); and reference to its use as an object of personal adornment may be read at least twice: "amber bracelets, beads" (*The Taming of the Shrew*, IV, 3, 58), and "necklace amber" in *A Winter's Tale* (IV, 4, 224). Evil or poisonous properties of minerals crop up in *Cymbeline* (V, 5, 50) as "a mortal mineral;" and in *Othello* (II, 1, 306) we read, "Doth like a poisonous mineral gnaw my inwards;" although, to be sure, "mineral" was doubtless a more inclusive term then than it is today and bore a broader connotation. In the same play (V, 2, 144), it is a little startling to find chrysolite cited. Bitumen is twice alluded to as a calking compound in *Pericles* (III, 1, 72, and III, 2, 57). Salt apparently was of interest strictly because of its taste and its presence in sea water, not as a mineral.

Shakespeare's list of metals is astonishingly brief. Many passages compare this or that to gold or silver or iron. But actual reference to these as metallic elements is less common. I noted five references to copper, forty-odd to iron, some twenty to lead, twenty-one to silver, nearly two hundred to gold, and but two to mercury (of course called "quicksilver"). It is indeed strange if this is the entire list. Where, for example is tin? Surely, the Cornish mines should have been known to Shakespeare, and, with such alloys as brass and bronze in daily use, it is odd to find tin omitted. If we digress a little from geology, we find some understanding of its allied fields, mining and metallurgy, in *All's Well That Ends Well* (III, 6, 39–40):

> to what metal this counterfeit lump
> Of ore will be melted,

in *Hamlet* (IV, 1, 25–27):

> like some ore
> Among a mineral or metals base,
> Shows itself pure,

and from *Henry IV*, Part I (I, 3, 60–63), I take:

> This villainous salt-petre should be digg'd
> Out of the bowels of the harmless earth,
> Which many-a good tall fellow had destroy'd
> so cowardly.

Further, from *Henry IV*, Part I (III, 1, 168–169), comes the expression "as bountiful as the mines of India," and in *Othello* there is mention of "rough quarries" (I, 3, 141) and "mines of sulphur" (III, 3, 329); *The Tempest* (I, 2, 254–255) supplies the slightly ambiguous phrase "to do me business in the veins of the earth."

Lime and its uses as mortar and cement are often mentioned, as one should expect, for the industry of limestone-burning was already old in England in Elizabethan times, and "the reek of the lime kiln" (*Merry Wives of Windsor*, III, 3, 86) had long offended men's nostrils. There are brief citations of lime or its use in *Coriolanus* (IV, 6, 85); *Henry VI*, Part III (V, 1, 84); *King John* (II, 1, 215–219); *Richard II* (III, 3, 26); and *Midsummer Night's Dream* (V, 1, 162). Mineral or mined coal as distinct from charcoal appears in the well-known line from *Henry IV*, Part II (II, 1, 95–96), "at the round table, by a seacoal fire," and in like words from *The Merry Wives of Windsor* (I, 4, 9–10), whereas in *Much Ado About Nothing* (III, 3, 11) there is introduced the minor character, George Seacole. The implication of the word "seacoal" or "seacole" is that such fuel had been mined at a distance and shipped by sea to London in contradistinction to the locally burned charcoal, which was hauled to the city in carts.

Rocks are neglected more than minerals. To be sure, there are such general terms as "harder than stones," "splitting rocks," and the like, but citations of specific kinds are comparatively rare. Probably the most-mentioned rock (or mineral, if you prefer) is flint, hailed for its hardness and its fire-producing quality. Marble comes in for more than its deserved share of fame, even though we disregard mere comparisons between it and human qualities. Its durability is praised in *Macbeth* (III, 4, 422), and mention made of its solubility in "much rain wears the marble" (*Henry VI*, Part III, III, 2, 49–50). Yet never a line did I find that touches upon granite, sandstone, or slate! Perhaps the nearest approach to any of these is "a freestone-coloured hand" (*As You Like It*, IV, 3, 25) freestone meaning Bath brick, a coarse sandstone. Also in *As You Like It* (I, 2, 57) whetstone is cited, and it occurs again in *Macbeth* (IV, 3, 228) and in *Troilus and Cressida* (V, 2, 75). Touchstone, besides appearing as the name of a character, has its use implied in *Pericles* (II, 2, 37): "gold that's by the touchstone tried." Chalk is occasionally mentioned, usually as the adjective "chalky." It was doubtless known to Shakespeare from its abundance in southern England, where it and flint occur naturally together.

Unconsolidated sediments and soils gain a share of attention. There is "Nilus' slime" in *Antony and Cleopatra* (I, 3, 69), and, in the same play, quicksands (II, 7, 65–66). Ooze is used and recurs in *Cymbeline* (IV, 2, 205–206); *Henry V* (I, 2, 164); *Pericles* (III, 1, 61); *The Tempest* (I, 2, 252–253). Sand or sands are often mentioned and sometimes their special attributes noted: as "one sand [grain] another not more resembles" (*Cymbeline*, V, 5, 120–121); and "sandy bottom'd Severn" (*Henry IV*, Part I, III, 1, 65); "congregated sands" (*Othello*, II, 1, 69); "yellow sands" (*Tempest*, 1, 2, 376). Movement of sand is described in *Titus Andronicus* (IV, 1, 104–105) as "the angry northern wind will blow these sands. . . ." Clay, shards, flints, pebbles, mud, marl, all are recorded. I shall mention but two citations on the soil; yet see how appreciation of its value and depletion are suggested in the lines from *Richard II* (III, 4, 38–39):

> The noisome weeds, which without profit suck
> The soil's fertility from wholesome flowers.

And observe also the informative passage from *Henry IV*, Part I (I, 1, 63–65), indicating the recognition of various soil kinds:

> Sir Walter Blunt, new lighted from his horse,
> Stain'd with the variations of each soil
> Betwixt that Holmedon and this seat of ours.

Prior to the mid-eighteenth century, few are the written proofs that men understood the true nature of fossils as evidence of ancient life. Is it then little wonder that Shakespeare has almost nothing to say on this phase of geology? To be sure, amber, which is fossilized tree gum, is mentioned (cf. *ante*). Shakespeare touches upon petrification in *Hamlet* (IV, 7, 20)—"like the spring that turneth wood to stone"—and there is a suggestion of the process in *Troilus and Cressida* (V, 10, 18).

In physiography and physiographic processes, interpreted liberally, Shakespeare's allusions to earth science are abundant and articulate. From *Antony and Cleopatra* (IV, 14, 5–6) we have:

> A pendent rock,
> A forked mountain, or blue promontory.

Plains and mountains are given scant treatment, the mountains more in the geographic than geologic category, including the Alps, Pyrenees, Apennines, Aetna, Olympus, the Taurus, and the Caucasus. Occasionally, there are indications of the characteristics of mountains, their weather, and climates. Of citations on cliffs, the finest is the descriptive passage on Dover Cliffs from *Lear* (IV, 6, 11–22):

Come on, sir; here's the place: stand still. How
fearful
And dizzy 'tis to cast one's eyes so low!
The crows and choughs that wing the midway air
Show scarce so gross as beetles: half way down
Hangs one that gathers samphire, a dreadful trade!
Methinks he seems no bigger than his head:
The fishermen that walk upon the beach
Appear like mice; and yond tall anchoring bark
Diminish'd to her cock; her cock, a buoy
Almost too small for sight: the murmuring surge
That on the unnumber'd idle pebbles chafes
Cannot be heard so high.

Turning next to the oceans, there are bits on straits and seas. Remarkable indeed is the comment in *Othello* (III, 3, 453–456) on the movement of the water of the Pontic (i.e., "Black") Sea:

Like the Pontic sea,
Whose icy current and compulsive course
Ne'er feels retiring ebb but keeps due on
To the Propontic and the Hellespont.

If I were to discuss fully the references to ocean water and its behavior, I should be obliged to include a tiresome succession of jottings on tides, particularly their relation to the phases of the moon, "the moist star upon whose influence Neptune's empire stands" (*Hamlet*, I, 1, 118–119). England's varied shores are impressively recognized in *Cymbeline* (III, 1, 18–22):

The natural bravery of your isle, which stands
As Neptune's park, ribbed and paled in
With rocks unscaleable and roaring waters,
With sands that will not bear your enemies' boats,
But suck them up to the topmast.

And, from *Henry V* (III, 1, 12–14), note undercutting by the battering waves:

As fearfully as doth a galled rock
O'erhang and jutty his confounded base,
Swill'd with the wild and wasteful ocean.

By contrast with the last, mark how the poet described, in the sixtieth Sonnet, lines 1–4, the ocean in a gentler mood:

Like as the waves make towards the pebbled shore,
So do our minutes hasten to their end;
Each changing place with that which goes before,
In sequent toil all forewards do contend.

Caves and caverns receive considerable attention, though usually in snatches too brief to warrant quoting. Some of the best are from *Antony and Cleopatra* (V, 2, 355); *As You Like It* (II, 7, 197; and V, 4, 202); *Cymbeline* (III, 3, 38); *Julius Caesar* (II, 1, 80–81); *Henry V* (II, 4, 124); *Henry IV*, Part II (III, 2, 88); *Richard II* (I, 1, 105); *Othello* (I, 3, 140); *Titus Andronicus* (II, 3, 24; III, 1, 271; IV, 2, 179; and V, 2, 35); *Twelfth Night* (IV, 1, 52); and *Two Gentlemen of Verona* (V, 3, 12).

In Shakespeare, as in Isaiah, there may have been an appreciation of denudation and wearing down of the land, illustrated in Sonnet LXIV (5–11):

When I have seen the hungry ocean gain
Advantage on the kingdom of the shore,
And the firm soil win of the watery main
Increasing store with loss and loss with store,
When I have seen such interchange of state,
Or state confounded to decay;
Ruin hath taught me thus to ruminate.

That understanding of the varied behavior of different kinds of rocks exposed to the elements was appreciated may be inferred through contrast of (and I again quote) "much rain wears the marble" (*Henry VI*, Part III, III, 2, 49–50) with "as unrelenting flint to drops of rain" (*Titus Andronicus*, II, 3, 141). Finally, there are those magnificent six lines from *Henry IV*, Part II (III, 1, 46–51), on the wasting away of the land, the interchange of land and sea:

And see the revolution of the times
Make mountains level, and the continent,
Weary of solid firmness, melt itself
Into the sea! And other times, to see
The beachy girdle of the ocean
Too wide for Neptune's hips.

Not to be omitted from among physiographic processes are the effects of running water and the behavior of streams. In *Antony and Cleopatra* (II, 2, 20–26), local color is introduced in:

Thus do they, sir; they take the flow o' the Nile
By certain scales i' the pyramid; they know,
By the height, the lowness, or the mean, if dearth
Or foison follow: the higher Nilus swells,
The more it promises: as it ebbs, the seedsman
Upon the slime and ooze scatters his grain,
And shortly comes to harvest.

Floods from melting mountain snows are touched upon in *Henry V* (III, 5, 50–52):

. . . the melted snow
Upon the valleys, whose low vassal seat
The Alps doth spit and void his rheum upon.

A receding inundation is described in *King John* (V, 4, 53–57):

Like a bated and retiring flood
Leaving our rankness and irregular course
Stoop low within those bounds we have o'erlook'd
And calmly run on in obedience
Even to our ocean.

Shakespeare mentions springs as now clear, now muddy, warm or cold, fresh or salt, and their effects upon man, either good or evil. By contrast, here are two beautiful lines from *Henry VIII* (I, 1, 154–155):

As clear as founts in July when
We see each grain of gravel,

and, from *Troilus and Cressida* (III, 3, 311–312):

My mind is troubled like a fountain stirr'd
And I myself see not the bottom of it.

The one hundred and fifty-third Sonnet, lines 4–8, lauds spring-water's curative powers:

In a cold valley-fountain of that ground;
Which borrow'd from this holy fire of Love
A dateless lively heat, still to endure,
And grew a seething bath, which yet men prove
Against strange maladies a sovereign cure.

But of all passages on the behavior of running water, these lines from *Henry IV*, Part I (III, 1, 98–114), astonish most because they show appreciation of changes in a meandering stream, means to control its wanderings:

Hot. See how this river comes me cranking in,
And cuts me from the best of all my land
A huge half-moon, a monstrous cantle out.
I'll have the current in this place damm'd up;
And here the smug and silver Trent shall run
In a new channel, fair and evenly;
It shall not wind with such a deep intent,
To rob me of so rich a bottom here.
Glend. Not wind, it shall, it must; you see it doth.
Mort. Yea, but
Mark how he bears his course, and runs me up
With like advantage on the other side,
Gelding the opposed continent as much
As on the other side it takes from you.
Wor. Yea, but a little change will trench him here,
And on this north side win this cape of land;
And then he runs straight and even.

The quiet current, deep and still, is distinguished from the shallow, turbulent stream in "smooth runs the water where the brook is deep" (*Henry VI*, Part II, III, 1, 53) and "shallow rivers, to whose falls" (*Merry Wives of Windsor*, III, 1, 17).

THESE flashes of geologic color have not been meant to prove that Shakespeare had an extraordinary comprehension of geological processes and phenomena. I have hoped only to demonstrate that in the time of Good Queen Bess there was among Englishmen a considerable knowledge of rocks and minerals, of the ocean and its behavior, and particularly that there was recognition of those larger features and processes we dub physiography. Even in Elizabethan times one might find "books in the running brooks, sermons in stones."

ABSTRACTS FOR THE PRESS

By HERBERT B. NICHOLS

Science Editor, The Christian Science Monitor, *and President, National Association of Science Writers.*

THE job of the science reporter is to bridge that gap between what literate people can reasonably be expected to know, and what the scientist has newly uncovered. No two readers ever have the same background or capability of understanding, so it is not possible to lay down any standard formula of exactly what should be told, or how it should be worded. Every science story has its own individuality, and for every reader it will have a slightly different meaning or point of contact.

What to tell the public and what to omit, involves all the "know-how" of the science reporter. It is his stock in trade as much as the knowledge of how to introduce novelty, interest, and knowledge in proper proportions in the classroom constitutes the stock in trade of the professor. When it comes to making science palatable for the layman, a stock answer popular among Army War College students applies here as well: "It all depends on the situation."

But this isn't much help to the scientist who wants to know exactly what he should do in preparing an abstract for the press. Should an abstract be written in the same manner, say, as one for *Chemical Abstracts* or *Biological Abstracts?*

No.

Such an abstract is, however, better than none at all. It gives the reporter who happened to major in chemistry or biology all he needs to know—perhaps. For the reporter who happened to major in astronomy or geology, the significance of the work may be entirely lost—his background for that particular story is limited or missing. Usually the paper will be thumbed through hurriedly, not touched at all unless a phrase or sentence happens to catch the eye and there's a glimmer of understanding—or there just isn't anything else to choose from that day.

A good rule to follow in writing for the science reporter is to consider him in the same light you would a student who has come to your laboratory for the first time, is interested in what you are doing, but has only a rather vague, general picture of what some of the problems are in your branch of science.

You wouldn't dismiss him with the loose statement: "We are engaged in considering some of the unexplained aspects of tropistic responses among the Compositae." That may be exactly correct, but it leaves so much unsaid that about the most intelligent reply you can expect to hear is, "Oh?"

A generalized sentence is equally unsatisfactory for the press. With 1,500 or more scheduled papers on a program, it is impossible for the reporter to follow up an abstract like that to see whether the work is really significant or not.

It would be much more valuable if the author would go on to say which tropisms were investigated and what the results of the work disclosed. Something of the methods employed, a few words about where the present work fits into the background of known facts concerning tropisms, and perhaps a hint of other problems still in need of study would not be amiss. One of the most successful professors I know never delivers a lecture without pointing out to his students several new avenues in need of research.

The length of the abstract depends upon how closely a subject comes to affecting the public. If the results are of value only

to "pure" science, of interest only because the findings add to our background of knowledge concerning tropisms, the abstract can be written in three or four short paragraphs.

But supposing the chemotropic response upon stimulation with a spray of 2,4-dichlorophenoxyacetic acid indicates that poison ivy and many other noxious weeds go into such spasms of cellular activity that they destroy themselves. There is now a very definite suggestion of a way such weeds can be eradicated, and the reporter would then like to know much more about the methods of study used, whether cytological work was accomplished, whether there is any connection with animal tropisms, how widespread the investigations are. In fact, a quite detailed abstract is called for. If patents have been applied for, or an industrial laboratory has taken an interest in the subject—perhaps started a pilot plant for the manufacture of the chemical—all this should be included in the abstract. It will save the reporter's time, and yours.

Even then, the chances are that the reporter would like to get hold of the whole paper. And he'll probably want an interview, perhaps want to send a photographer out to your laboratory to make some on-the-scene shots.

The fact that the score or so of science reporters and editors who follow scientific conventions around the country, much like sports reporters follow the world series games, all seem to choose the same papers to write about in each session would indicate that there must be some general criterion for making a choice. There is. That factor is "interest" or "possible future value to civilization." Thus, stories of progress in industrial engineering or the applied sciences are more often used than reports from the so-called pure sciences.

In order to qualify as news there must be some point of contact between the subject under investigation and the public. Much depends upon the social meaning or utilitarian value of research, its possibilities after further development by the engineer, the manufacturer, the ultimate consumer; but more often the determining factor in whether a science story makes front page, jump page, zee-whiz box, or round file (where most press-agent copy and free advertising handouts end their little hours) is the amount of human interest the story carries.

The more often an abstract makes the reporter say to himself, "That's interesting, I didn't know that before," the more often a good newspaper story will be printed, and the closer it will be to what the scientist would like to see associated with his name. The longer the technical man can hold the interest of the reporter with his abstract, the less room there will be for editorializing or adding background and side remarks.

Back in the 1920's science writers began the practice of "grading" the papers presented at scientific meetings—not from the standpoint of scientific worth, but as potential newscopy. The practice has not been used so much in recent years because of the chagrin many eminent scientists show when their papers turn up with a "D." "A" is the highest grade, of course, and goes to those reports that have wide public interest, that are well presented, and that have sufficient "quotable quotes" to give them authority and meaning. "B" tells the tardy reporter skimming through the abstracts that here is something pretty good, not front-page copy, but a story that's all there and worth while telegraphing or cabling. A "C" story is one that's technical but significant in its field, requiring considerable additions from the reporter's background of knowledge. A "D" report is one that's hopelessly technical, of interest only to mathematicians or abstract scientists, or perhaps too insignificant to bother with.

Celebrities at a convention—presidents

or directors of large scientific bodies, Nobel prize winners, men and women who have made headlines before—always rate "A" no matter what their abstracts say. If they aren't complete enough, or clear, then delegations from the fourth estate will ask for a complete paper or an interview or both.

In the A.A.A.S. it is frequently difficult for the press to find enough in the abstracts to meet its need. Too many speakers send in no abstract at all, furnish only the title, or write a single sentence intended either to discourage the reporter or cause him to seek out the author. Stories made up of names and filled with titles and generalizations are of small or no value to reporters of large metropolitan dailies. Some scientific organizations, such as the American Chemical Society, will not permit a paper to be listed on the program unless the author makes some attempt to send in a suitable abstract in advance of the meeting.

Secretaries of the various Sections or some other designated officer could perform a great service to the press if they would either confer with Dr. Sidney Negus, the A.A.A.S. press representative, or send in written informal comments—not for publication—concerning which papers in their sections are most significant and which need to be taken with a grain of salt.

But, most important of all, each speaker should mail in *something* by way of an abstract, and do it early.

HEADQUARTERS ASSIGNMENTS

A partial list of headquarters assignments for the Sections and societies that will meet with the A.A.A.S. at Chicago, December 26–31, 1947, is given below. The Sherman Hotel will be the general headquarters for the meeting.

CONGRESS HOTEL
- American Association of Economic Entomologists
- American Microscopical Society
- American Society of Naturalists
- American Society of Parasitologists
- Beta Beta Beta
- Ecological Society of America
- Entomological Society of America
- Phi Sigma Society (Council only)
- Society for the Study of Evolution

PALMER HOUSE
- Sections B* and O
- American Association of Physics Teachers*
- American Dietetic Association
- American Meteorological Society*
- American Physical Society*
- American Society for Horticultural Science
- Honor Society of Phi Kappa Phi
- Philosophy of Science Association
- Pi Lambda Theta
- Potato Association of America
- Sigma Pi Sigma
- Society for Research in Child Development

SHERMAN HOTEL
- Sections A, C, D, E, H, I, K, L, M, Nd, Nm, Np, and Q.
- Academy of World Economics
- American Chemical Society, Chicago Section
- American Nature Study Society
- Cooperative Committee on Science Teaching of A.A.A.S.
- National Association of Biology Teachers
- National Science Teachers Association
- Pi Gamma Mu
- Research Council on Problems of Alcohol
- Sigma Delta Epsilon
- Society of the Sigma Xi

STEVENS HOTEL
- Sections F and G
- American Fern Society
- American Phytopathological Society
- American Society of Plant Physiologists
- American Society of Plant Taxonomists
- American Society of Zoologists
- Botanical Society of America, Inc.
- Genetics Society of America
- Herpetologists League
- Limnological Society of America
- Mycological Society of America
- Sullivant Moss Society

* Meetings will be held on campus of The University of Chicago.

IT'S A DATE

By SAMUEL G. BARTON

Professor Barton (Ph.D., Pennsylvania, 1906) is a member of the Department of Astronomy at the University of Pennsylvania. During World War I, he was Director of the U. S. Shipping Board Navigation School and, during World War II, an instructor in the U. S. Navy Pre-flight School. To readers interested in pursuing the subject of this essay further, Dr. Barton recommends The Calendar, by J. K. Fotheringham, in the British Nautical Almanac, *1931; and* Handbook of Dates for Students of English History. *London: Royal Historical Society, 1945. The latter contains an excellent bibliography on chronology.*

SIR ISAAC NEWTON, the greatest astronomer, and probably the greatest scientist, of all time, was born in Woolsthorpe, England, sometime in the year 1642 or 1643. The date is left thus indefinite because I have found, in what are usually regarded as at least moderately reliable sources of information—biographies, histories, encyclopedias, treatises on astronomy and on physics, and the like—the following given as the date of his birth: January 4, 1642; January 5, 1642; December 5, 1642; December 25, 1642; January 4, 1643; and January 5, 1643.

There is no real uncertainty as to the date of his birth but, even if there were, there should be none about the date of his death, for few men were more famous. His death was world-wide news. Nevertheless, I find given as the date of his death March 21, 1725; March 20, 1726; March 3, 1727; March 20, 1727; March 31, 1727; and May 20, 1727.

It is probably impossible to account for some of these dates except by attributing them to gross carelessness. A likely, or at least possible, explanation can be given for some of them. Some are correct when properly interpreted. The errors show that otherwise well-educated persons need information on the subject of calendars and that a rediscussion of it should be of value.

In such a discussion certain facts must be kept clearly in mind. From the time of the establishment of the Julian calendar, in 45 B. C., until October 1582, this calendar was in general use. In it every fourth year is a leap year. With our present system of numbering years from the supposed year of the birth of Christ (which system, however, was not introduced until A. D. 525 and was little used until the eighth century), the leap years, in the A. D. period, are those years (with the year beginning January 1) whose numbers are evenly divisible by four.

Under the Julian calendar various dates have been used as the beginning of the year, chiefly January 1, March 1, March 25, and December 25. Convincing evidence that Augustus Caesar did not change the number of days in August, as is commonly stated, is given by Lamont in an article on the Roman calendar in *Popular Astronomy*, November 1919. It is to be hoped that the erroneous statement will not be repeated.

Two changes were made in the Julian calendar in 1582, primarily for religious reasons connected with the celebration of Easter. Ten days were dropped from the calendar, the day following October 4 of that year being called October 15. Furthermore, all future century years, all of which would be leap years by the Julian calendar, were to be leap years only if their numbers were evenly divisible by 400. Thus 1600 was a leap year in the new calendar, as in the old, but not 1700, 1800, and 1900. The beginning of the year was definitely set at January 1.

This slightly modified calendar is called the Gregorian calendar. The Julian calen-

dar, however, continued in use in many places. It was used in England and her colonies until 1752; it was retained in Russia until 1918, in Greece and Rumania until 1924, and in Turkey until 1927.

Since these two calendars have been in use simultaneously in different parts of the world, it is frequently necessary to distinguish between them. A date in the Gregorian system is designated as New Style (N.S.), and one in the Julian system as Old Style (O.S.). This distinction should always be made where there can be reasonable doubt, but, unfortunately, it is not, and sometimes the terms New and Old Style are used in a different sense. Dates of events between 1582 and 1752, in England and America, are particularly capable of misinterpretation when not so designated.

With these facts in mind, we can discuss the discrepancies in the dates relating to Newton and trace the sources of confusion. Newton was born December 25, 1642, by the Julian calendar, the one then in use in England, his native country. He was born January 4, 1643, by the Gregorian calendar —a different month, a different day, a different year. The difference between the two calendars was then still 10 days.

Wolf, apparently using a difference of 11 days instead of 10, states in his *Geschichte der Astronomie* that Newton was born in "Whoolstorpe," January 5, 1643. This misinformation, including the misspelling of Woolsthorpe, was evidently copied in *La Grande Encyclopédie* and in Newcomb-Engelmann's *Populäre Astronomie* (7th ed., p. 811). (There is a similar error in the date of the death of Tycho Brahe.) Dessauer, in his life of Newton (p. 400), makes the same mistake in the date. The day was Christmas Day in England, but not where the Gregorian calendar was in use. It was Thursday, however, everywhere, as the succession of weekdays was not disturbed by the change in the calendar.

If the year was considered as beginning on March 1 or on March 25, with an otherwise Gregorian date, as was sometimes done, Hazeltine's date,[1] January 4, 1642, is not impossible, but doubtless she simply erred in a curious way. Dessauer's discussion (p. 399) shows some such reasoning in obtaining his date, January 5, 1642. The date December 5, 1642, is presumably intended to be December 25, 1642. It is given in Winkler Prins, *Algemeene Encyclopaedia*.

Newton died March 20, 1727, by the Julian calendar, with the year beginning January 1. With the year beginning March 25, the date would be March 20, 1726, as given in *La Grande Encyclopédie*. By the Gregorian calendar the date was March 31, 1727. At this time the difference between the two calendars was 11 days, since the year 1700 was not a leap year in the Gregorian calendar. It is not hard to believe that March 3, 1727, the date of death given by Berry in *A Short History of Astronomy* (p. 241), is a misprint for March 31, 1727, and that May 20, 1727, given in *Enciclopedia Universal Illustrada* is a misprint for Mar. 20, 1727. The date March 21, 1725, given in Winkler Prins, is a mystery.

It is commonly said that Newton was born in the same year that Galileo died. Galileo died January 8, 1642, Gregorian calendar, but in that system Newton was born January 4, 1643, which is not in the same year numerically, although the two events were less than a year apart. Galileo's death occurred December 29, 1641, in the Julian calendar, which again is not the year of Newton's birth.

In England, in early times, the year began December 25, but from late in the twelfth century the legal year began March 25, and the same was true in English colonies. March 25 commemorates the announcement to Mary that Christ would be born (Luke 1:26–38), just as Christmas commemorates His birth. March 25 is the day of the Feast

of the Annunciation and is commonly known as Lady Day. January 1, however, was customarily called New Year's Day, and New Year's gifts were presented to the kings and queens at this time.

Thus, for all dates between January 1 and March 24, inclusive, there is uncertainty as to the year number to be associated with the Julian date. This uncertainty is increased by the fact that March 25 was not used as the beginning of the year in Scotland, and that it was used at various times in countries other than England and her colonies. This uncertainty was usually removed, especially in later times, by writing a double date. Thus, the record in the family Bible states of George Washington[2] that he "was born y^{e} 11th Day of February 1731/2 about 10 in the morning." This indicates that the year of his birth was 1731 for those who began their years with March 25, and 1732 for those beginning the year with January 1.

But suppose that only one year number is given for such a date—how is the date then to be interpreted? For instance, on the tablet concerning Newton in Westminster Abbey, we find the inscription[3] "*Obiit xx Mar. MDCCXXVII;*" that is, he died on the twentieth of March, 1727. Our previous discussion shows that this is the date if the year began January 1. Are we safe then in assuming that other such dates should be interpreted in this manner? On the monument to Queen Elizabeth in the Abbey we find the inscription[4] "*Obiit 24 Martii, Anno Salutis MDCII;*" that is, she died on the twenty-fourth of March, in the Year of Salvation 1602. We know that she died March 24, 1602/3, so this inscription uses March 25 as the beginning of the year.

Although Newton usually dated his letters properly, that is, without this ambiguity, he was not entirely consistent, for we find a letter to Halley[5] dated "Feb. 18, 1686," meaning "1686/7;" another, to Dr. Mill,[6] is dated "Jan. 29, 1694," meaning "1693/4." Francis Bacon consistently used years beginning March 25 without the use of double dates. Newton dated one of his letters[7]

$$\text{Jan. 11th, } 8\frac{7}{8}$$

and received one from his nephew Humphrey Newton dated in the rather curious manner,[8]

$$\text{January 17, } -2\frac{7}{8}.$$

The century number, 16, being supposed obvious, is omitted in the first case, and 17 is replaced by the dash in the second, just as we might write a date as July 4, 47, or, better, July 4, '47. The latter part of the date might have been written 87/8 or 87–8.

Newton wrote one date as "March 2, 1674 O. S."[9] where Old Style is used to indicate years beginning March 25, and not a date in the Julian rather than in the Gregorian system—its usual significance. Instead of using O.S. or N.S., frequently both dates are given in a combined form. Thus Leibnitz, residing in Germany, where the Gregorian calendar was in use, writing to Newton, in England, where the Julian was in use, dated his letter [10]

$$\frac{7}{17} \text{ March, 1693,}$$

the upper being the Julian date. This might possibly be misinterpreted in England. At any rate, Flamsteed is more specific in writing his date[11] as "Feb. 17–27, 1680–1." A similar but more complex date written in this style is

$$\frac{28}{9} \text{ day of } \frac{\text{November}}{\text{December}} \text{ 1713,}$$

and the still more complex date of Newton's birth is

$$\frac{25}{4} \frac{\text{December}}{\text{January}} \frac{1642.}{1643}$$

It is now customary to give the year of a Julian date of a historic event as though the year began January 1, regardless of the practice at the time and place of the event. Such a date is called the historical date; but of

course there are authors who are either careless or ignorant, and care is needed to be sure that the dates in the original sources are correctly interpreted.

The decree of Pope Gregory XIII ordering the adoption of the Gregorian calendar is "dated at Tusculum in the year of the Incarnation of our Lord one thousand five hundred and eighty first, the sixth of the calends of March, of our pontificate the year 10." The equivalent of this date is February 24, 1581, Julian calendar of course. The Pope, however, did not begin his years with January 1, so the historical date is February 24, 1582, and that is the date that would normally be given. Similarly, by the original record, Marco Polo died January 8, 1323, but since in Venice the years then began March 1, not January 1, the historical date is January 8, 1324.

Julius Caesar is commonly supposed to have made January 1 the beginning of the year. Beginning about the seventh century, the church preferred to begin the year with one of its festivals, such as Christmas Day, Lady Day, or Easter Day. In the Middle Ages, in certain religious or ecclesiastical connections, March was considered to be the first month of the year, and certain computations were based upon March 1 as the beginning of the year. This day was so used, however, for these special purposes only and was not in general use, although there were a few places where the year numbers changed on March 1, notably at Venice. In the later centuries of the Middle Ages, January 1 gradually came into greater favor, and it was definitely made the beginning of the year in the Gregorian calendar in 1582.

It is of particular interest to note that the Quakers, in England and America, and perhaps elsewhere, until 1752 called March the "First Month" and designated the others correspondingly, February being to them "Twelfth Month." Franklin, in *Poor Richard's Almanacks* (famous in their day and still so), used years numbered as beginning January 1, but the month itself was designated as "XI Mon. January;" that is, Franklin, too, designated January as the "Eleventh Month," and he continued to do so until 1752. There are other very interesting points about the Quaker calendar, which I shall not discuss here.

As already stated, March 25, Lady Day, was commonly used as the beginning of the year. When, in 1744, Easter Day coincided with Lady Day, Franklin's *Almanack* designates the day as "Easter Day in my Lady's lap." Queen Elizabeth died on March 24. Her contemporaries termed this day "Lady's Eve" and "Our Lady Even," just as we speak of New Year's Eve.

The *Encyclopaedia Britannica*, under the heading "New Year's Day," gives the following misinformation: "The first day of the year. In the Gregorian calendar this occurs 12 days earlier than in the Julian; thus New Year's Day is the English 13th of January." The intended meaning of the preceding sentence is not clear. The facts are that the difference between the dates in the two calendars has been 13 days since 1900 and that the Julian New Year's Day now falls on January 14 of the Gregorian calendar.

Notwithstanding the different days for beginning the year, February 29, the extra day inserted in leap years, was the same day. Thus, although Washington was born in 1731, counting March 25 as the beginning of the year, February 29 was inserted in that year, even though 1731 is not evenly divisible by four. Jefferson's father was born[12] February 29, 1707–8.

THE dates of events in English history are expressed in the Julian calendar, that is, as Old Style dates, until 1752. The custom in the United States differs in that we frequently express the dates of events in

our history between 1582 and 1752 in the Gregorian calendar, that is, in the New Style. We did not have the large number of important historical events in this interval that England had, and it is perhaps simpler to have these dates expressed in the system now used, thus having a single system. This is debatable, however.

To illustrate, both in the United States and in England, Columbus would be said to have discovered America on October 12, 1492, just as Columbus himself recorded the date; but many of us, at least, say that the Pilgrims landed at Plymouth on December 21, 1620, although they recorded the date as December 11, 1620, and the English would so date events on that day. The English will tell you that the Astronomer Royal Maskelyne was born October 6, 1732. Had he been born in this country we would change the date to the Gregorian system, as we do with the date of Washington's birth in the same year, and say that he was born October 17, 1732. There is the greater reason for doing this when the person concerned was alive in 1752, when the calendar was changed. We would not transform the dates of English history in this manner.

There is an enormous amount of inconsistency in the matter. Historians and others dealing with dates frequently, if not usually, give dates in this interval without the slightest indication as to whether they are Julian or Gregorian, and if one is determined to find out which by hunting through the original sources—a thing he should not be obliged to do—he finds it difficult to locate them. Often some dates are given by an author in one system and some in the other without distinction. Some dodge the point by giving the year only.

Suppose that we are treating of William Penn, who was born in England and who died there, but who lived for a time in Pennsylvania and was very important in its history—how shall we date his life? Both the *Encyclopaedia Britannica* and the *New International Encyclopedia* state that he was born October 14, 1644, and that he died May 30, 1718, without stating which system of dating is used. It is Old Style; but the fact is that he died July 30 and not May 30, 1718. This error evidently resulted from a misinterpretation of the expression "Fifth Month."

The same ideas prevail in the times of the celebration of anniversaries of historic events. For dates prior to 1582 the original date is used. Thus, Columbus Day, which commemorates the discovery of America, is October 12. Christmas Day, the anniversary of the birth of Christ, was celebrated on the same date, December 25, the supposed true date of the event, in both the Julian and the Gregorian calendars, although this was not actually the same day.

However, when the four hundredth anniversary of the discovery of America was celebrated by the World's Columbian Exposition, the grounds were formally dedicated "On Oct. 21, 1892—corresponding to Oct. 12, 1492" (*Encyclopaedia Britannica*, 5, 145). Here the Gregorian system was applied by extrapolation to a date prior to its creation—an unusual procedure.

For events in the history of the United States later than 1582, we in the United States usually celebrate on the Gregorian date, even though the Julian calendar was in use at the time and place of the event. As examples we have William Penn's birthday (Pennsylvania Day, in Pennsylvania) on October 24, not October 14; Franklin's birthday (Poor Richard Day), January 17, not January 6; Washington's Birthday, February 22, not February 11. Georgia Day is February 12, not February 1, when Oglethorpe landed, in 1733.

Note, however, that Forefathers' Day, which commemorates the landing of the

Pilgrims, is December 22, although they landed on December 21, 1620, which is December 11, 1620, O.S. The explanation is that the Old Colony Club started the celebration of the day in 1769, which was shortly after the adoption of the Gregorian calendar. Eleven days were added to the Julian date, which was the correct difference in 1769 but not in 1620. The erroneous day for celebration has been used ever since. No one pointed out the error until 1832.

The custom in England is different. There events are commemorated in the Gregorian system on the same date as that on which they occurred in the Julian. Thus the bicentenary of the death of Newton was considered to be March 20, 1927, and not March 31, 1927, as we would have considered it. The main features of the celebration were on March 19, since the twentieth fell on Sunday. Sir Christopher Wren died February 26, 1723, O.S. A bicentenary service was held February 26, 1923. When the event is one of English history such as these, we in the United States are likely to conform to the English system, although I suppose that there is no rigid rule.

Tycho Brahe was born December 14, 1546, between nine and ten o'clock in the morning, as we state the fact. Tycho himself, however, in several places[13] alludes to December 13 as his birthday. The reason is that Tycho used astronomical time, in which the days begin at noon rather than at midnight. As this system was not used by the general public, I shall explain further.

The bill to improve the calendar introduced in the House of Representatives by Representative Kee (H. R. 1345) states that the Gregorian change "entailed a loss of two Fridays, two Saturdays, and two Sundays, and one Monday, Tuesday, Wednesday, and Thursday; or one week and three days of that year." This is an erroneous statement. In the change, Thursday, October 4, 1582, was followed by Friday, October 5, Julian, and by Friday, October 15, Gregorian. The dates October 5–14, inclusive, were dropped, but the succession of weekdays was retained. The combined year 1582, Julian and Gregorian, contained but 365 days, and the weekdays lost were those corresponding to December 22–31, Julian, which went into the year 1583, Gregorian. December 22 was Saturday, so the loss was two Saturdays, etc., and not the days with the names of October 5–14, Julian, given in the bill.

Although all the confusion that has just been discussed and illustrated does not arise from the so-called Gregorian reform of the calendar, I think that the reader should by this time be softened up enough, to use the military expression, to appreciate the background giving rise to the following comment on this change by Newcomb, the greatest astronomer America has produced. In his book *Popular Astronomy* (New York: American Book Co., p. 50), he says:

> If there were any object in having the calendar and astronomical years in exact coincidence, the Gregorian year would be accurate enough for all practical purposes during many centuries. In fact, however, it is difficult to show what practical object is to be attained by seeking for any such coincidence. It is important that seed-time and harvest, shall occur at the same time through several successive generations: but it is not of the slightest importance that they should occur at the same time now that they did 5000 years ago, nor would it cause any difficulty to our descendents of 5000 years hence if the equinox should occur in the middle of February, as would be the case should the Julian calendar have been continued.
>
> The change met with much popular opposition and it may hereafter be conceded that in this instance the common sense of the people was more nearly right than the wisdom of the learned. An additional complication was introduced into the reckoning of time without any other real object than that of making Easter come out at the right time.

Another complication is introduced by the Gregorian calendar. It is a common statement that the length of the saros, the

eclipse cycle, is 18 years, 11⅓ days, or 18 years, 10⅓ days, according as four or five leap years are included in the interval. The fact that, by the Gregorian calendar, at times only three leap years are included is usually overlooked or at least not stated. A better statement is that the saros is equal to 18 calendar years plus 10⅓ days if five leap days (February 29) are included, 11⅓ days if but four are included, and 12⅓ days if but three are included, as may happen when a century year not a leap year, such as 1900, is involved. The saroses including the years 1582 or 1752 require special consideration.

As those who read about the reasons for the Gregorian change usually, I think, get a much exaggerated idea of the importance of the fact that the Julian year is a bit too long, thus causing the seasons to come one day earlier in an interval of 128 years, I amplify Newcomb's statement by calling attention to the fact that one may travel by air from the middle latitudes of the Northern Hemisphere to those of the Southern Hemisphere in a few days and by so doing completely reverse the seasons. Even more to the point are the facts brought out in an article in *The Sky* (March 1939), "The Vagaries of the Seasons," by Dr. E. W. Woolard.

Dr. Woolard shows, in particular, that in the United States the number of days intervening between the day of the summer solstice and the average day of highest normal temperature, the lag of the season, varies from 10 days at El Paso, Texas, to 100 days at San Francisco, Calif. At Sacramento, less than 100 miles inland, the interval is but 37 days. Thus there is a difference of 63 days in the times of the hottest day at San Francisco and at Sacramento, which are no great distance apart. Any place may have a late or early spring or other season, in any year.

While on this subject, how can I neglect mention of Phileas Fogg, who, according to Jules Verne, wagered that he could make the tour of the world in eighty days? Having started at 8:45 P. M., Wednesday, October 2, he was due to return before 8:45 P. M., Saturday, December 21. He arrived in London at 8:50 P. M., Saturday, December 21, only five minutes too late, financially ruined, as he supposed.

The next day, nevertheless, faithful Aouda asks, "Will you have me for your wife?" (It was in the year 1872, a leap year.) He replies, "Yes . . . Will it be for to-morrow, Monday?" She agrees, "Yes, for to-morrow, Monday." (In this day she would have replied, "O. K. It's a date.") But the clergyman decided that marriage "tomorrow" was impossible as that day was Sunday. An error in Mr. Fogg's date was thus discovered. There was a mad rush to the starting point, The Reform Club, and the journey was completed within the time limit by the narrowest of margins. Mr. Fogg had traveled around the world eastward but, extremely meticulous though he was, had failed to drop a day from his dates on crossing the international date line. Considering that hectic journey, one can scarcely blame him.

REFERENCES

1. HAZELTINE, MARY E. *Anniversaries and Holidays*, 4.
2. WILSON, W. *Life of Washington*, 41.
3. BREWSTER, D. *Memoirs of Newton*, 2, 394.
4. NICHOLS, J. *Progresses of Queen Elizabeth*, 3, 650.
5. BREWSTER, D. *Memoirs of Newton*, 1, 455, 475.
6. ———. *ibid.*, 2, 141.
7. ———. *ibid.*, 2, 548.
8. ———. *ibid.*, 2, 95.
9. MORE, L. T. *Isaac Newton*, 170.
10. BREWSTER, D. *Memoirs of Newton*, 2, 120.
11. BAILY, F. *Life of Flamsteed*, 123.
12. JEFFERSON, T. *Writings*, 1, 1.
13. DREYER, J. *Tycho Brahe*, 12.

THE ROYAL SOCIETY AND AMERICAN SCHOLARS

By MARGARET DENNY

Miss Denny (M.A., Smith), Assistant Professor of English at the University of Rochester, is interested in the history of ideas, particularly the impact of scientific ideas and practice upon certain representative seventeenth- and eighteenth-century Americans. Her article on the influence of the Royal Society in America from 1663 to 1800 is based on a paper presented at a meeting of the Modern Language Association in Washington.

THERE is general agreement that the Royal Society of London exerted a profound influence upon Americans during the colonial period. There is reason to believe, also, that the Society's influence did not terminate with the American Revolution, since it is obvious that the first two independent scientific societies in this country, the American Philosophical Society, at Philadelphia, and the American Academy of Arts and Sciences, at Boston—both recipients of state charters in 1780—bear marked resemblances to the Royal Society in plan of organization, procedure, and scientific objectives. This imitation of the English organization indicates that colonial Americans had been impressed by the successful methods employed by the Royal Society in propagandizing scientific doctrine and in recruiting scientific practitioners.

During the first half-century of our national history, the scientific temper among Americans became more vigorous and pervasive. Not only was there an astonishing increase in activity among scientists, but the general public came to see science as a way of life and to discover that scientific methods were applicable to a wide variety of human pursuits. The part played by the American scientific society in this education of Americans was probably not unlike that of the Royal Society in England, which, in the seventeenth and eighteenth centuries, had been most successful in the development of many English "virtuosi." Once these amateurs perceived science as a medium for the "relief of man's estate," they were tireless cooperators with the Society in its efforts to improve natural philosophy.

What, first of all, were the principal methods used by the Royal Society for teaching and guiding its natural philosophers? Why were such means considered effective by the Americans who chose to follow the London plan? Obviously, the success of the Society's methods should be reflected in the reactions of those colonial Americans who had come under the Society's influence. In order to obtain answers to these questions, I have arbitrarily selected material that I believe will most clearly reveal this interaction of Royal Society and American scientists.

The fourteen colonial Americans chosen for particular study were:

Governor John Winthrop, Connecticut, an original Fellow (F.R.S., 1663)
William Byrd, Esq., Virginia (F.R.S., 1696)
Governor William Burnet, New York, New Jersey, and Massachusetts (F.R.S., 1706)
The Reverend Cotton Mather, Massachusetts (F.R.S., Council vote, 1713; Assembly vote, 1723)
Judge Paul Dudley, Massachusetts (F.R.S., 1721)
Dr. Thomas Robie, Massachusetts (F.R.S., 1725)
Dr. Zabdiel Boylston, Massachusetts (F.R.S., 1726)
John Winthrop, Esq., Connecticut (F.R.S., 1734)
Dr. John Mitchell, Virginia (F.R.S., 1748)
Governor Francis Fauquier, Virginia (F.R.S., 1756)
Benjamin Franklin, Pennsylvania (F.R.S., 1756)
Professor John Winthrop, Massachusetts (Hollis Professor of Astronomy and Natural Philosophy, Harvard) (F.R.S., 1766)
Dr. Arthur Lee, Virginia (F.R.S., 1766)
Dr. Alexander Garden, S. Carolina (F.R.S., 1773)

Because all these men had been elected

Fellows of the Royal Society, I could believe that the Society had successfully brought them into its orbit. There were, of course, more than fourteen Americans who belonged to the Society during the colonial period (see the complete list compiled by R. P. Stearns, *William and Mary Quarterly*, April 1946), but the men I have chosen differ from the other Fellows in that their contributions were printed in *Philosophical Transactions*. Assuming that publication in the *Transactions* was a mark of the Society's approval, I believe that a study of the American Fellows' choice of subject and treatment of material will throw light on the program of work that was being currently recommended by the Society, as well as suggest the effect this program was having on American scientific activity. The *Transactions* printed not more than three papers contributed by most of these American Fellows. In contrast there are the ten communications by Professor Winthrop and by Franklin and the twelve papers by Judge Dudley.

Even at the risk of superficial treatment and repetition of facts already well known, I have chosen to view the scientific activity of the fourteen men as a whole. I have tried to see in perspective the century between Governor Winthrop's first publication in 1670 and the account by Alexander Garden that appeared in 1777. Points of kinship have been sought, and the leading tendencies in eighteenth-century science observed.

It is to the credit of the Royal Society that from the outset of its organized activity it assumed the role of educator, for certainly the progress of science was contingent on mass education in the scientific method. In general, only a few points were given special emphasis, but these were repeated over and over again. Many were the echoes of Francis Bacon's words: "We must lead men to the particulars themselves and their series and order." The end pursued by the Society, like that of Bacon's Salomon's House, was "the knowledge of causes and the secret motions of things; and the enlarging of the human empire, to the effecting of all things possible."

By means of the three-hour discussions and demonstrations at the weekly London meetings of the Society, the correspondence and conversations of individual Fellows, and the selected papers that appeared in *Philosophical Transactions*, the Society propagandized scientific method and terminology. In the *Transactions* the work of fact gathering was always called a "relation" or an "account" or a "history." To describe another type of scientific research the words uniformly used were "observations," "causes," "hypotheses," "thoughts," or "suppositions." Constant repetition of terms and multiple papers exemplifying each phase of the scientific method—these comprised the Society's mode of indoctrination.

This educational influence, however, needed to be supplemented by one more direct and dynamic. If scientists could be induced to work cooperatively upon a common problem, they would prove that in truth "many hands make light work." Only experience would convince the worker that in science the policy "what's yours is mine" was not only a good but an essential one. The machinery of the Society's organization was designed, therefore, to make sure that the Fellows worked cooperatively and that their scientific finds were pooled. Among the many devices for stimulating cooperative work on specific problems were the recommendations that came from the eight standing committees created in 1664. The Society assumed the responsibility of keeping each Fellow informed—by way of the *Transactions* if he lived far from London—of the various studies that merited his cooperation. The

Fellow, in turn, promised "to promote the good of the Society;" in practice this meant that he would become conversant with the program of scientific work then being sponsored by the Society and that he would make every possible contribution to that program.

In addition, the Society functioned as custodian of the treasures of the museum and of the papers deposited in the archives. Respect was due these archives because they made it possible for the individual scientist to make use of the discoveries and reports of his colleagues. Many depositors in this international bank of scientific data were needed, and of this the Society's Fellows appear to have been aware. Benjamin Franklin interpreted his election to membership as obliging him to send in that portion of his private correspondence that had reference to the Society's current projects. For a number of months following his election in April 1756, Franklin's exchanges of letters with James Bowdoin, of Massachusetts, and with Cadwallader Colden, of New York, as well as letters from other Americans, were read at the meetings of the Society in London.

How assiduously the Society collected material for its archives may be surmised from the circumstances that led to the election of the two Bostonians William Brattle and John Leverett in 1714. The Society wanted the scientific papers of the late Thomas Brattle, of Cambridge; these were intended to supplement the account of eclipses that had appeared in the *Transactions* of 1704 and 1707. It is probable that Isaac Newton's reference in his second edition of the *Principia* to Brattle's observations of the 1680 comet prompted the Society's interest in the work of the American astronomer. The task of obtaining the papers from William Brattle, his brother's heir, fell to the secretary of the Society. For advice on strategy he turned to Henry Newman, who while at Harvard had assisted Brattle in his observations. Newman suggested the gift of membership to Brattle; and, because Newman must have been familiar with the Damon-Pythias relationship between William Brattle and John Leverett, the election of the latter was also recommended.

The journal-book of the Society reports that Leverett accepted the honor but that Brattle declined it on the ground that he was "unqualified." This appears curious to the twentieth-century observer. Both Brattle and Leverett had long been champions of the new science; they had both done yeoman service for natural philosophy at Harvard College. To an eighteenth-century scholar, familiar with the responsibilities of membership in the Royal Society, however, the behavior of Leverett and Brattle would be proper and consistent. In 1714 Leverett, as President of Harvard College, could "promote the good of the Society" by fostering the scientific spirit at that institution. But Brattle was no longer a tutor at Harvard and could not join Leverett in this indirect service to the Society. When he refused the title of Fellow he served notice that he did not intend to become a co-worker with the Society, did not intend, in short, to do more than deposit his brother's papers in the archives of the Society.

Both early and late colonial Fellows showed that they understood their election committed them to a contract with the Society quite as much as it conferred on them a signal honor. Upon receiving news of his election in 1713, Cotton Mather assured the Society's secretary of his "firm resolution to have annually as long as [he might] live, contributed unto its Treasures." In reply to a letter from an English friend, which described Alexander Garden's election into the Society, the new American Fellow wrote:

> I do not know the usual mode or form of thanking them . . . please to inform me of the common

method followed on such occasions. This, at least, you may assure them of; my earnest endeavours to serve them in any thing I can, and to promote their plan in every way in my power.

Because the newly elected Fellow could believe he had entered into a covenant with the Society, he naturally might look on the first paper submitted after his election as a pledge of his good faith. Garden bemoaned the inadequacy of this paper. He had attempted, while recovering from a severe fever, to describe and analyze his five electric eels from Surinam, and he greatly feared that he "was little able either to examine these fish accurately, or to digest what few trials [he] could make of their properties." Had Garden been less hasty in sending off his account, he might have made good use of a pertinent article "On the electrical power of the Torpedo" in the *Transactions* that soon came to hand. Professor Winthrop presented his *Thoughts on Comets* (1767) "to the most illustrious Royal Society on account of the great honor" recently conferred on him. His paper was written in Latin, a practice frowned upon by the Society. But I fancy the members were loathe to chide a Fellow whose work had such a gratifyingly solemn tone of dedication. Besides, Winthrop's paper, both in method and material, was precisely the type the Society most desired at that time.

To the new Fellow, his "election paper" might be unique, but to the Society it was usually only one in a series of papers already received from the scientist. Some Americans, on the other hand, sent in material to London, answered the inquiries of Fellows of the Society, and even had articles printed in the *Transactions*, but never received the Society's reward of membership. Students wishing to uncover reasons why the names of certain Americans do not appear on the Society's list of members might well keep in mind the following regulations of the Society: First, the eighteenth-century American had to be recommended by three Fellows instead of the single sponsor required in the preceding century; second, the candidate's name could not appear on the list of Fellows until he had made a sworn statement that he would work for the good of the Society. Those "signing the obligation" (as it was termed) were, after 1753, charged a fee of twenty-one guineas; an additional ten guineas was required of Fellows elected after 1766. Finally, both the Council and the General Assembly had to agree that the candidate would be "useful to the Society." Peter Collinson, because he corresponded with so many American scientists, was the member of the Society best fitted to sponsor their candidacy. Was he negligent? Perhaps Collinson's correspondents were not doing work on which the Society's attention was focused at that time. A correlative study of Collinson's papers and the Society's journal-book might be illuminating.

A great deal of publicity was given to Franklin's election. This may have arisen from the unconventional nature of the circumstances. Franklin was surprised by the Society's action because, so he said, "It was not usual . . . to choose persons into the Royal Society, who had not requested to be admitted." The tone of the entry in the Society's journal-book suggests that it was equally unusual for the members to vote that "the Name of Mr. Benjamin Franklin . . . be inserted in the Lists before his Admission and without any Fee, or any other payment to the Society." Obviously, the procedure concerning election into the Society was well established, and general knowledge of it abroad could be assumed.

Important elements in the pattern of behavior proper for the Society and the candidate may be deduced from the correspondence of Alexander Garden with the English Fellow John Ellis. The negotiation

began with the candidate's expression of interest in membership. Thereafter, however, the initiative became the English Fellow's. Believing that the scientist's cooperative spirit, his interest, and energy, would make him a "useful and valuable member" of the Society, the English Fellow first outlined to him the responsibilities of membership, both scientific and monetary, and then inquired whether these terms were agreeable to him. Upon receipt of an affirmative answer, the Fellow then reported that his candidate wished to become a member. Thereupon the Fellow and two other sponsors composed the certificate of recommendation describing the candidate's qualifications, and the voting in of the new member followed with little or no delay.

Whatever may have been the negotiations preceding Zabdiel Boylston's election in 1726, they must have seemed dull indeed in comparison with the events of five years before, when Dr. Boylston was proving his worth to humanity and to science during the memorable epidemic of smallpox in Boston. It is ironical that Cotton Mather had to borrow from Dr. Douglass, the inveterate foe of inoculation, the volume of the *Transactions* containing the description of the method of inoculation used in Constantinople. Dr. Douglass refused to permit publication of the two reports of the method, and Mather perforce had to make abridgments; these Dr. Boylston had printed in the Boston papers. At length the epidemic was brought under control, and science thereby won a stunning victory over prejudice. In the year following the furor at Boston the Royal Society received from that city an account of the "way of proceeding in the smallpox inoculated in New England." When this famous inoculator was made a Fellow in 1726, the London members had every reason to consider that Dr. Boylston would be a "useful and valuable" member of the Society.

How decisively the Society's current program dominated the scientific investigation of the early American colonial Fellows is immediately apparent. That program was the compilation of a mammoth natural history. Historical data concerning all places and all subjects were first to be collected by means of the cooperative efforts of as many people as possible, and then that material was to be stored in the archives of the Society—"laid up [said the Society's curator, Robert Hooke] only in Heaps as it were, as in a Granary or Store-House; from thence afterward to be transcribed, fitted, ordered and rang'd and tabled . . . to be made fit for use." That a definitive history of the various countries of the world was a major project of the Society is indicated by the heading of the index to the first volume of *Philosophical Transactions:* "A Natural History of all Countries and Places is the foundation for solid philosophy."

The Society made the work of its many cooperators much easier and more efficient by supplying instruction as to the historical data desired. These directions, according to Hooke, were phrased as queries "so as any that shall have an Opportunity and willing to promote this Design may accordingly [choose] the things . . . most likely to be instructive for the discovering of the true Nature of that which he inquires into." In 1661 the Society created a special committee to compile inquiries for historians in distant lands; Robert Boyle's model outline was published in the *Transactions*' initial volume and was called "General heads for a natural history of a country, great or small."

In the early days the Society relied upon its colonial Fellows to act as foreign correspondents, who, by frequent communication with the Society's Secretary or with active Fellows, would keep abreast of the Society's activities; it was also hoped that they would recruit cooperators in their

special districts and would lend a hand if the Society sent out natural historians to gather material. In the seventeenth century Governor Winthrop, in Connecticut, and William Byrd, in Virginia, seem to have functioned as foreign correspondents of the Society to some degree. Both also sent in accounts of American natural history, and in 1694 Byrd carried to England a female opossum, which was duly dissected and reported upon by the English Fellow Edward Tyson.

It was quite natural that during this history-making period any man who showed a willingness to gather and accurately report facts would receive the Society's encouragement, and if his quantity of output—either potential or already contributed—were great enough, he usually was made a Fellow. Cotton Mather was so cooperative and industrious in work for the English Fellows Woodward and Petiver that he was soon recommended for membership, and he remained true to his promise to make annual contributions to the archives in London. Mather, in turn, persuaded John Winthrop, Esq., of Connecticut, to collect fossils for Woodward. In 1734 Winthrop was the donor of what "constituted for its time the largest single gift presented to the Society." The *Philosophical Transactions* of 1738 was dedicated to Winthrop, and in the preface the Society's thanks were expressed for the grand total of six hundred specimens Winthrop had deposited in the museum of the Society.

From 1713 until his death, another New Englander, Thomas Robie, was identified with the monumental collection of meteorological data that the English scientist William Derham was directing.

Of the group of New Englanders who were Fellows of the Society in the early eighteenth century only Paul Dudley does not appear to have begun his work for the Society as the satellite of some English Fellow who was a projector of a large history collection. Dudley set to work on a history of his own—a proposed history of the American Indian, which was almost certainly inspired by his reading of a paper in the *Transactions*.

There was another type of data collection strongly encouraged by the Society, which only the virtuoso with some technical skill could undertake. From Volume IV to Volume L (1669–1758) the *Philosophical Transactions* contained articles that were grouped in the index under the title "Attempts at the discovery of the longitudes of places." Men living overseas who were adept at astronomical observation could make valuable contributions to the cause of science by sending to London their accounts of eclipses. A comparison of their calculations with those of London observers made possible a more exact determination of longitude. An English Fellow, James Hodgson, compared his 1703 observations with those of Thomas Brattle and reported in the *Transactions* his estimate of the longitude of Cambridge. Because Governor William Burnet, of New York, sent in his observations of the eclipses of the first satellite of Jupiter in 1724 and 1725, the London observer, Astronomer Royal James Bradley, was able to determine the longitude of the fort of New York.

The Society's program of data collection dominated the work of the early American Fellows, and it influenced to some degree the work of later colonial scientists. Governor Fauquier, of Virginia, described "an extraordinary storm of hail" that occurred in 1758. Professor Winthrop submitted an account of the earthquake of 1755, taking care to follow the same pattern of presentation used in Paul Dudley's paper, which had appeared in the *Transactions* of 1735. When the Society was collecting meteorological data for the year 1760, conditions in New England were reported by Winthrop. His observation of the transit of Mercury

in 1743, he believed, would "determine the longitude of Cambridge, New England, with more exactness than any of the observations that have been used for that purpose." In addition to a full description of the electric eel, Alexander Garden cheerfully gathered data for such London Fellows as Stephen Hales, John Ellis, Henry Baker, and Thomas Pennant. In one of John Mitchell's papers he presented first a historical account of other methods of manufacturing potash before describing the improved method he strongly recommended.

In general, however, the contributions sent in by American Fellows late in the colonial period differed markedly from earlier ones. It is noticeable, also, that the articles appearing in *Philosophical Transactions* carried a different emphasis. Whereas previously the papers had usually been designated "accounts"—the unmistakable mark of the historical paper—those now appearing stressed "causes, conjectures, hypotheses, thoughts." This was a far cry from Robert Hooke's seventeenth-century ultimatum to the Society's members:

> . . .till there is a sufficient collection made of experiments, histories, and observations, there are no debates to be held at the weekly meetings of the Society concerning any hypothesis or principal [sic] of philosophy, nor any discourses for explicating any phenomena, except by special appointment of the Society or allowance of the President.

Now, however, the aim of the Society's research had become "the knowledge of causes and the secret motions of things," and the focus of attention was upon principles and the application of principles rather than upon fact per se.

A review of the articles in *Philosophical Transactions* suggests that during this period three types of scientific investigation were particularly favored. (From one of these, however, American Fellows were debarred because the material lodged in the London archives was not available to them.) One of the English Fellows, in a paper entitled "Conjectures concerning the cause, and observations upon the phenomena of earthquakes" (1760), had examined the Society's data on earthquakes and had made good use of the histories sent in by Winthrop and Dudley.

The Society also publicized the discoveries resulting from the correct application of such recently expounded principles as those of Newton and Linnaeus. Linnaeus was not made a foreign Fellow of the Society until 1753, but by that election the Society acknowledged the contribution he had already made to science. In 1744 Peter Collinson had reported to Linnaeus:

> Your system, I can tell you, obtains much in America. Mr. Clayton and Dr. Colden at Albany on Hudson's river in New York, are complete professors; as is Dr. Mitchell at Urbana on Rapahanock river in Virginia. It is he that has made many and great discoveries in the vegetable world.

The popular judgment concerning the writings of Linnaeus was probably echoed by Alexander Garden when he wrote:

> These have first introduced into Botany the science of demonstration, founded upon mathematical principles; and at the same time a sound, as well as easy mode of classification.

In the mid-fifties, Garden, by this time one of the American disciples of Linnaeus, was himself making "many and great discoveries." The English Fellow John Ellis was most anxious to have Garden's descriptions of his new genera published in the *Transactions*, but Garden offered the Society only a few of his Carolina plants. Most of his material was sent to Linnaeus. John Mitchell also carried on a correspondence with Linnaeus between 1745 and 1750; in the course of this exchange of letters Mitchell obtained the data on the manufacture of potash that he presented to the Society in 1748.

It was natural, if only because Newton was President of the Society during the first quarter of the century, that the

early eighteenth-century American Fellows should follow his career with interest. Champions of Newton showed concern for their favorite in the battle of words then raging. Paul Dudley asked the advice of the Society's Secretary concerning "a new treatise of philosophy in opposition to Sir Isaac Newton," which he had seen advertised. "I should be glad," he said, "to have your opinion of the book and whether it be worthy sending for."

The principal interest of the later American colonial Fellows, however, centered on the principles Newton had set down in the *Principia* and the *Optics*. By 1752 an American correspondent could remind Franklin, "On this occasion I think it proper to observe to you that in the [*Optics*], what Sir Isaac has proved is generally taken for granted and supposed to be known." Even passing comments concerning Newton refer to the Newtonian theories rather than to the man. Garden found it "surprising to see how exactly the various phaenomena of the indigo beating, quadrate with and confirm Sir Isaac's theory of the composition of colorific particles of bodies."

The American Fellows who appear to have studied and applied Newtonian principles most effectively were Dr. Mitchell and Professor Winthrop. In 1744 Mitchell's paper, entitled "On the causes of the different colours of people in different climates," was read at two meetings of the Society; it is reported that the Society's members were much impressed by this "very curious dissertation concerning the Colour of the skin in Negroes." Mitchell's reliance on Newtonian principles is indicated by his reference to the *Optics* thirteen times in a paper of forty-eight pages.

Frederick Brasch is of the opinion that Professor Winthrop was "Newton's first critical disciple in the American colonies." Certainly *Thoughts on Comets* reflects Newtonian influence at every point. Winthrop had derived the solutions to the five problems which were posed from the principles set forth in the *Principia*. There is reason to believe Winthrop intended his paper to be a supplement to Newton's work. The form of his paper closely followed that of the *Principia*, and the only footnote references were to that work. In 1774 the *Transactions* printed Winthrop's "Remarks upon a passage in Castillione's Life of Sir Isaac Newton," in which Winthrop protested against the biographer's misinterpretation of Pemberton's text and expressed fear that Newton would thereby be put in an inferior light "in the eyes of foreigners."

A third type of scientific investigation given publication in the *Transactions* was one indicating the value of the experimental method advocated and outlined in Newton's two famous works. Newton's emphasis on "experiments and observations" made that term a commonplace. It is highly improbable that Benjamin Franklin chose only by accident the title *Experiments and Observations* for the volume on which his fame as a scientist largely rests. Franklin's friend Dr. Arthur Lee, in the year of his election into the Society, submitted a series of twenty-five experiments on the Peruvian Bark. The opening words of his paper reveal how thoroughly conversant he was with the patter in vogue during this particular period. "The object of experiments," he announced, "is to establish principles, on which practice may be conducted in the most expeditious and unerring manner."

Just as the Society sponsored and directed the project of history collection in the earlier days, so between the forties and the seventies the Society no less vigorously encouraged cooperative work on two problems considered at that time to be of major importance. These were the determination of the nature and properties of electricity and the "grand problem of the parallax," as Professor Winthrop phrased it. The

transits of Venus over the sun in 1761 and 1769 offered two golden opportunities for solving the latter problem.

Obviously, the exact determination of the sun's distance from the earth was not possible unless many astronomers submitted their observations for comparative study. Therefore, from *Philosophical Transactions* came Professor Hornsby's pleas for cooperation, and the London Fellow who was the Astronomer Royal issued a pamphlet of detailed instructions. The Professor of Astronomy at Harvard College did not need reminders from London of the importance of the two events, but the trouble Winthrop took in order that his account of the 1761 transit should reach London indicated how anxious he was to contribute his share in the cooperative work the Society was directing. He sent in his original report to an English Fellow; a popular account of the transit he published in Boston. The absence of Winthrop's observations from Volume LII of the *Transactions*, which was devoted almost exclusively to reports submitted by observers, probably prompted Winthrop to send a second letter. When in 1764 he learned that an English Fellow had access only to the Boston account, Winthrop once again repeated his description and made certain of ease of mind by requesting publication of his letter in the *Transactions*. His observation of the transit of 1769 reached London without mishap.

On January 2, 1769, the American Philosophical Society united, on terms of equality, with the American Society held at Philadelphia for Promoting Useful Knowledge. The first major cooperative project after this merger of the two rival scientific societies was the 1769 transit of Venus. Perhaps Benjamin Franklin, the newly elected president of the society at Philadelphia, encouraged cooperation with the Royal Society; certainly he saw to it in 1768 that the instructions of the Astronomer Royal reached Professor Winthrop's hands.

The Society's program for research on electricity was probably spearheaded by William Watson who, in 1745 and 1746, read a series of papers before the Society. In his discourse entitled "Experiments and observations tending to illustrate the nature and properties of electricity," Watson reviewed all the important electrical experiments that had been made; he recommended that in the future cooperators in research on electricity adopt Newton's experimental method outlined in the *Optics;* and he closed his long account by listing ten queries on electricity designed to provoke and guide future investigation. The Society had long used this device of publishing desiderata on a subject as a means of recruiting more workers. By March 1747 Franklin was thanking Peter Collinson for "your kind present of an electric tube, with directions for using it." And that marked, of course, the beginning of his remarkable electrical experiment and discovery.

Franklin immediately identified himself with the work being done by the Society's experimenters. Indeed, I. Bernard Cohen, editor of *Benjamin Franklin's "Experiments and Observations"* (1941), believes that the influence on Franklin of the articles appearing in the *Transactions* and of such works as Watson's was so strong as to be detrimental. Certainly the *Transactions'* influence upon Franklin was as sudden as it was strong. In his paper of 1737, entitled "Causes of Earthquakes," which appeared in the *Pennsylvania Gazette*, Franklin cited the *Transactions* of no later date than the seventeenth century. Had he been familiar with Dudley's account of earthquakes that appeared in the 1735 *Transactions*, he undoubtedly would have included it in his compilation. Because from the outset of his experiments Franklin was intent on discovering something "new,"

it was necessary that he acquaint himself with the electrical research already done. It is, therefore, not surprising that four months after his thank-you note to Collinson Franklin showed himself thoroughly conversant with the current *Transactions*.

By 1752, when Franklin's own papers began appearing in the *Transactions*, his role in the Royal Society was largely one of judge and counselor. He added his explanation to that of Gowin Knight concerning the electrical phenomena described by Captain Waddell; he supplemented the experiments of John Canton and correlated the work of Canton and of Delaval. Franklin's "letter concerning an electrical kite" contained an account of a decisive experiment through which he verified his own hypothesis.

Such was the Society's respect for Franklin's opinions that it solicited his "remarks on Beccaria's experiments in electricity." When inquiry was current regarding the possible use of electricity in paralytic cases, the Society asked for a report from Franklin. In 1773 he was asked to serve on one of the Society's committees, and his report explained why his pointed (rather than Wilson's blunted) lightning rods were being recommended for use on the powder magazines at Purfleet. The prestige Franklin enjoyed is suggested by the action of the Royal Society in awarding him the Copley Medal even before he was elected a member.

Although the study of electricity resulted in no discoveries by other American Fellows, the subject was of absorbing interest to them. It required an exchange of five letters for Professor Winthrop fully to confide his thoughts on electricity to Franklin. Alexander Garden's behavior was typical. Like Franklin, he was sent a piece of electrical apparatus by an English Fellow; like the other zealous virtuosi, he showed familiarity with the literature of electricity; and, like all scientists of this period, he did not hesitate to indulge in suppositions.

THESE American Fellows of the late colonial period showed a strikingly different attitude toward their own work and their status as scientists from that of such a man as Paul Dudley, whose collection of historical data had been made earlier in the eighteenth century. Dudley wrote to the Society's Secretary in 1723:

> I am very glad what I sent. . .came safe to the Society, not that anything of mine is really worth their acceptance, but that they will be convinced at least how willing I am to make some return for their great respect to me, besides the incouragement it will give me to repeat my duty by the next conveyance. . . .Sir your very affectionate humble servant.

Although the phrasing of the close of his letter was conventional, it described Dudley's spirit precisely.

Quite different is the correspondence of Garden regarding the specimens he sent to Upsala. Garden seemed to relish his debates with the great Linnaeus. On one occasion, when Linnaeus had been the loser, Garden reported to John Ellis: "I came off conqueror in our dispute about the new genus *Anamelis*, on which I plume myself not a little, but his candour charms me."

John Mitchell believed his observations on the "Colour of the skin in Negroes" good enough to be offered in competition for a prize, but because his paper did not arrive at Bordeaux by the required date, it could not be judged. All these circumstances were explained by Peter Collinson when he presented Mitchell's paper to the Royal Society in 1744.

By 1754 Franklin could feel he was no longer under any obligation to answer his opponents personally. ". . . will not one's vanity," he wrote James Bowdoin, "be more gratified in seeing one's adversary confuted by a disciple, than even by one's self?"

Professor Winthrop's experience of 1769 should have been an object lesson in self-confidence. During his observation of the second transit of Venus he made a discovery that he knew would challenge a theory held by two distinguished English Fellows. Winthrop's incertitude was apparent when he wrote to Franklin in London, "I will make no doubt you will immediately discover where the error lies and shall take it as a great favour if you will point it out to me." Back came the report on the test the Society had commissioned Richard Price to make: "Your ingenious friend," he announced to Franklin, "is right."

One factor inducing this change of attitude in the American Fellows is that, whereas the early work done for the Society required of the men only zeal and accuracy, work of the later period brought into play not merely the simplest but the highest mental powers. The very form of the papers would provoke different attitudes: one was factual exposition; the other, argument by proof.

Another reason why these men respected their own work is perhaps too obvious for comment. The particular emphasis the Society was giving scientific investigation during this period stimulated the active cooperation of men schooled in scientific learning and techniques. Most of the late colonial Fellows—Winthrop, Mitchell, Garden, Lee (Franklin being the glaring exception)—were professional scientists. Since cooperation had become a matter of course to these men, they no longer needed instruction from the Society as to its virtues. Franklin and Winthrop showed their mastery of the cooperative technique by initiating their own projects of cooperative work. One example was Winthrop's organization of the expedition to Newfoundland in order to observe the transit of Venus in 1761. From an account in *Sky and Telescope* (1943) we learn that numerous American observers in 1769 looked to Winthrop as their director.

Franklin's behavior in 1753 showed how welcome was any opportunity to supervise a cooperative venture. In that year a French correspondent of the Academy of Sciences had dispatched from Paris a letter to the astronomers at Quebec, asking them to contribute observations of the transit of Mercury. The letter, which came to New York en route to Canada, was unsealed, and perhaps for that reason the reading of it provoked no pangs of conscience. At once the instructions to the astronomers were copied, translated, and sent to Philadelphia. Franklin struck off fifty copies and gave them wide distribution. The report from Franklin's cooperator at Antigua was printed in the *Transactions*, in it the correspondent gently chided Franklin for sending half a dozen circulars when one was sufficient for the few men at Antigua interested in astronomy.

Alexander Garden did not direct a cooperative project, but he showed himself capable of outlining strategy for a proposed cooperative gardening experiment in Charleston and other colonial centers.

To the earlier colonial Fellows London had seemed the center of their scientific world; it was not so to the Americans of the later period. Garden, for example, worked with a will for English Fellows, but his major activity was the collection of American flora and fauna for Linnaeus. Garden had already been honored by membership in the scientific societies at Edinburgh and Upsala when in 1773 he was made a member of the Royal Society.

Perhaps the earlier Fellows had tended to move wholly within the orbit of the Society because they were elected to membership soon after they had begun their scientific activity. Unlike these men, Professor Winthrop began contributing papers to the Society in 1740; yet twenty-five years later Ezra Stiles reminded Franklin,

"I hope you will not forget to recommend that ingenious and learned gentleman, Professor Winthrop, to the honors of the Royal Society, now that you are in London." Franklin's contributions flowed to London in a steady stream for nine years before the Society voted him a Fellow.

What had caused this delay in the election of Winthrop or, indeed, of Franklin was not, I think, lack of appreciation of either their genius or their service to the Society. The policies and procedures of the Society were not static, but they did not keep pace with the growth of science. Early in the century the Society had been able to use the bait of election into the Society as a means of increasing scientific work. As the century advanced, however, productive scientists became so numerous that the Society was no longer prompt in awarding membership to its own cooperators, and policy regarding membership became increasingly cautious.

There is little evidence that the Society's neglect or its restrictive measures concerning new members aroused resentment in the Americans. Apparently, their scientific progress rather than their *amour-propre* was the first concern of these men. A serious obstacle to that progress, Alexander Garden believed, was not removed merely by election into the Society. When he was informed of the fee required of the newly elected member, he wrote:

> I think it would be very needless in me to advance 25 guineas for the name, as I should never have any access to that instructive conversation, which you who reside in London must mutually enjoy at your meetings. . . .Hence, though the sum be inconsiderable, yet I judge it would be mis-spent.

Garden thus clearly implied that the scientist's major need was the stimulation and assistance offered by the exchange of ideas, of experience, and of material between scientists at work on the same problems. But, if colonial Americans were to profit by exchange of scientific opinions, they had to carry on as large a correspondence as possible with scientists both overseas and at home.

Of this Benjamin Franklin was fully aware. His 1743 proposal for an American colonial scientific society was modeled on the Royal Society, but the difference between the two plans is significant. The committees of the Society usually initiated and directed scientific investigation; Franklin's were intended to function largely as committees on correspondence. The chairmen were to direct letters of inquiry and comment coming into Philadelphia to the scientists who shared the interests of the correspondents.

Certainly the colonials would not be content to rely wholly on their correspondence from across the seas, however. The long delay in receiving a reply and the frequency with which letters and specimens failed to reach their destination would increase the desire of Americans to find more satisfactory means of filling this need of close and constant contact with fellow-scientists. The value of "instructive conversation" had been proved by Garden when his visit at New York with Cadwallader Colden in 1754 inspired him to begin his correspondence with Linnaeus and to undertake a botanical study of the Charleston district. Franklin was fortunate to find in Philadelphia three such fellow-experimenters in electricity as Kinnersley and Syng and Hopkinson. Was it not almost inevitable, therefore, that the American scientists should seek some means of meeting regularly and forming a permanent organization? Hence, the two American colonial Assemblies in 1780 did only what was to be expected when they granted charters to the American Philosophical Society held at Philadelphia for Promoting Useful Knowledge and the American Academy of Arts and Sciences at Boston. It was, however, most unlikely that American scientists would completely ignore the

work issuing from London merely because for reasons of efficiency the small independent societies had been created.

Of necessity, the Royal Society's attitude toward American scientists underwent a change at the time of the Revolution. Those Americans who had previously been termed Home Fellows became Foreign Fellows; in the future the Society was to consider eligible for election only those Americans whose reputation as distinguished scientists had already become world-wide. Thus, the Royal Society stood ready to honor America's men of scientific genius, but it no longer essayed the discovery of scientific talent and the development of the scientific temper among Americans. It therefore became the responsibility of the societies in this country to encourage and advise American scientists, amateur or professional, and to educate the American public in scientific objectives and techniques.

Because the societies at Philadelphia and Boston were so patently modeled on the Royal Society, Americans must have believed that the English organizational plan was in general a good one. Is it not probable, however, that these American societies were less duplicates than adaptations of the London plan? New times and conditions usually require some changes in traditional method. Why these methods were altered and what were the consequences of such modifications are questions which, if answered, might well explain to some degree the tempo of scientific growth in America in the years following the Revolution.

The Philadelphia Society for Promoting Agriculture, for example, corresponds in function to the georgical committee of the Royal Society. Did the creation of an independent organization result in more efficient work? Did it provoke greater public interest, an increased number of cooperators? Were Fellows of the American Philosophical Society also members of the group promoting agriculture, or did they function in an advisory capacity?

Philosophical Transactions was issued a number of times each year, but the journals of the American societies appeared so infrequently that the scientists themselves—much less the general public—could not promptly learn of the latest scientific discoveries. Only by publications supplementary to the *Transactions* of the American societies could the literature of science flow in a steady stream to the scientist, the mechanic, the farmer. To what degree was the American society aware of this need? What steps were taken to fill it?

Students of American intellectual history would be particularly interested to learn if adaptations of the English practices resulted in a more widespread and effective education of the common man in the aims and methods of science. Since Americans came firmly to believe that the pursuit of happiness was somehow linked with the progress of science, and that if men worked together in the true spirit of cooperation they could hope for success in the human adventure, it is desirable to know what role the American scientific society may have played in the formation of such popular concepts as these.

In colonial times the Royal Society had furnished Americans the encouragement and supervision they sorely needed. The Society's plan of organization and membership and its promotional tactics had made it possible for a direct influence to be exerted upon the men of this country. My notes upon the work and attitude of fourteen of the Society's American Fellows may have suggested how profound and how formative that influence was.

LOUIS AGASSIZ AND MEN OF LETTERS*

By JAMES D. TELLER

Dr. Teller (Ph.D., Ohio State) taught the history of science and of education at OSU from 1938 to 1943. During the war he was a research psychologist with the Army's Personnel Research Section, which constructed and validated all mental tests used in the selection and placement of men in the Army. His present duties as Chief of Employee Evaluation for The Adjutant General's Office, War Department, are a natural evolution. Dr. Teller's article celebrates the centennial of Louis Agassiz' arrival in the United States.

THE influence of Louis Agassiz on men of science is well known. His influence is attested not only by men of science, however, but also by men of letters. Although Henry David Thoreau was one of Agassiz' first collectors in America, he had no love for classification or dissection. He would send Agassiz a fish from the Concord River without wishing to know where Agassiz placed it in the scheme of the universe or what he found when he dissected it. Nevertheless, Agassiz never failed to cultivate Thoreau's society when he could. Thus, in declining Thoreau's request in 1849 that he lecture in Bangor, Agassiz pleads:

> My only business is my intercourse with nature; and could I do without draughtsmen, lithographers, etc., I could live still more retired. This will satisfy you that whenever you come this way I shall be delighted to see you,—since I have heard something of your mode of living.

The author, however, tended to avoid the man of science, although he recognized in Agassiz the qualities that gave him so much distinction.

In contrast with his relations with the recluse of Walden Pond, Agassiz was from the first a much-loved guest of George Ticknor's house. In spite of their differences, they took great pleasure in each other's company. As a trustee of the Museum, Ticknor often counseled with Agassiz. In a letter to Lyell dated April 5, 1848, Ticknor writes:

> Agassiz continues to flourish, and enjoys the same sort of popular favor he has from the first. His bonhomie seems inexhaustible; and how much that does for a man under institutions and in a state of society like ours I need not tell.

Ticknor and Agassiz both belonged to the "Friday Club." This was a dinner club formed in 1859. It was limited to twelve members and met once a fortnight. In addition to Agassiz and Ticknor, its membership included W. Amory, Sidney Bartlett, B. R. Curtis, C. C. Felton, W. W. Greenough, G. S. Hillard, R. M. Mason, W. B. Rogers, C. W. Storey, and H. P. Sturgis.

The Friday Club, however, was neither the first nor the most brilliant of the clubs with which Agassiz was associated. Two or three years before it was founded, a literary association, which finally became known as the "Saturday Club," had crystallized out of certain informal social meetings of a group of friends at "Parkers," "the 'Will's Coffee House' of Boston." The Club seemed to have shaped itself around the dinner meetings of Ralph Waldo Emerson and two or three of his friends. Gradually the little company gathered others to itself, until a group unique in the intellectual eminence of its members had been assembled. Some of these were contributors to *The Atlantic Monthly*, but the Club was not connected with the magazine. Holmes believed that

* References to quotations have been omitted at the request of the Editor.

the vitality of the Club was due to "its utter poverty in statutes and by-laws; its entire absence of formality, and its blessed freedom from speech-making."

The early group brought together by the Club is enumerated by Holmes as follows:

> During its first decade the Saturday Club brought together, as members or as visitors, many distinguished persons. At one end of the table sat Longfellow, florid, quiet, benignant, soft-voiced, a most agreeable rather than a brilliant talker, but a man upon whom it was always pleasant to look,—whose silence was better than many another man's conversation. At the other end of the table sat Agassiz, robust, sanguine, animated, full of talk, boylike in his laughter. The stranger who should have asked who were the men ranged along the sides of the table would have heard in answer the names of Hawthorne, Motley, Dana, Lowell, Whipple, Peirce, the distinguished mathematician, Judge Hoar, eminent at the bar and in the cabinet, Dwight, the leading musical critic of Boston for a whole generation, Sumner, the academic champion of freedom, Andrew, "the great War Governor" of Massachusetts, Dr. Howe, the philanthropist, William Hunt, the painter, with others not unworthy of such company. And with these, generally near the Longfellow end of the table, sat Emerson, talking in low tones and carefully measured utterances to his neighbor, or listening, and recording on his mental phonograph any stray word worth remembering.

Of the fifteen persons listed by Holmes, ten are included in Emerson's list of twelve members for 1856. Hawthorne, Sumner, Andrew, Howe, and Hunt are not included. However, S. G. Ward and H. Woodman are listed. Holmes himself, along with C. C. Felton and J. E. Cabot, appears first in Emerson's list for 1857. The Club had also had among its members James T. Fields, William H. Prescott, Henry James, W. D. Howells, T. B. Aldrich, Charles Francis Adams, Francis Parkman, and many more scarcely less well known.

Holmes did not object when someone referred to the Club as "The Mutual Admiration Society," for he thought that "all generous companies of artists, authors, philanthropists, men of science, are, or ought to be, Societies of Mutual Admiration." Whipple, however, believed that admission to the Club "depended rather on antipathy than sympathy as regards the character and pursuits of its members." Agassiz prized the Club because of the opportunities it afforded him for meeting with persons who were not particularly interested in the subjects that absorbed his own intellect and taste.

Brief descriptions of three meetings of the Club at different times in its history will serve to illustrate Agassiz' intimate relations with its members. One of the early meetings of the Club was that in honor of his fiftieth birthday on May 23, 1857. In reporting it Emerson entered the following lines in his *Journal:*

> Agassiz brought what had just been sent him, the last coloured plates to conclude the First Volume of his Contributions, etc., which will now be published incontinently. The flower of the feast was the reading of three poems, written by our three poets, for the occasion. The first by Longfellow, who presided; the second by Holmes; the third by Lowell; all excellent in their way.

Longfellow wrote in his *Journal* that they "sat down at half-past three, and stayed till nine." It was at this meeting that Longfellow read in a "very modest, delicate musical way" the charming poem that begins as follows:

> It was fifty years ago
> In the pleasant month of May,
> In the beautiful Pays de Vaud,
> A child in its cradle lay.
>
> And Nature, the old nurse, took
> The child upon her knee,
> Saying: "Here is a story-book
> Thy Father has written for thee."

Whipple says that Agassiz shed tears as the last stanza referring to his mother was read.

On April 23, 1864, the Club met "to keep the birthnight of Shakespeare, at the end of

the third century." Seventeen members and fifteen guests were present. William Hunt sent a full-length picture of Hamlet. Emerson reports that "it was a quiet and happy evening filled with many good speeches, from Agassiz who presided (with Longfellow as *croupier*, but silent), . . . and a fine poem by Holmes. . . ."

Although it was almost impossible to induce Longfellow to speak in public, even when he was called upon at the dinner to the Grand Duke, Holmes tells us that "at the last Club he offered the health of Agassiz—who was just about to leave on an exploring expedition of the Pacific Coasts of South America,—and made a very neat little speech, which was received with much applause. . . ." Longfellow himself writes in his *Journal* for November 26, 1871:

> Drove over to the Navy Yard in the afternoon with my girls to see the little steamer (the "Hassler") in which Agassiz is going round the Cape. Yesterday at the Club dinner we drank his health at parting. I proposed it thus: "Gentlemen, I am reminded that we shall not again have with us for a year and a day our dear Agassiz, who sits there at the head of the table so joyous and unconcerned. I shall, therefore, for once break through our usual custom and propose his health. Wordsworth once said that he could have written the plays of Shakespeare if he had had a mind to. And I suppose that on an occasion like this I could make a speech,—if I had a mind to. But I shall do nothing of the kind; I shall limit myself to proposing "The health of Agassiz; his deepest sea-soundings shall not be deeper than our love and admiration for him."

Something of the intimacy of Agassiz' relations with his fellow-clubmembers can be obtained from James Russell Lowell's description of the Club as he presents it in his elegy on Agassiz.

The brilliance of the meetings of the Saturday Club can be better appreciated from a remark Lowell made in a letter written in 1883 to C. E. Norton telling about the cultural advantages of his dearly beloved London. He writes:

> In plain living and high thinking I fancy we have, or used to have, the advantage, and I have never seen society on the whole, so good as I used to meet at our Saturday Club.

Holmes, too, expresses a high appreciation of the Club in a letter to Motley dated February 16, 1861:

> The Club has flourished greatly, and proved to all of us a source of the greatest delight. I do not believe there ever were such agreeable periodical meetings in Boston as these we have had at Parker's.

Few of the members of the Club were as sentimentally attached to it as was Holmes. In later years, as death began to claim the early members of the Club, there came to be something pathetic about his attachment to that which still had existence but which was, for him, almost all a memory. In 1883, after Agassiz, Longfellow, and Emerson had died, he wrote to Lowell in England:

> I go to the Saturday Club quite regularly, but the company is more of ghosts than of flesh and blood for me. I carry a stranger there now and then, introduce him to the members who happen to be there, and then say: "There at that end used to sit Agassiz,—here at this end, Longfellow,—Emerson used to be there, and Lowell often next to him . . . .

Holmes had a great admiration for Agassiz and used to call him " 'Liebig's Extract' of the wisdom of ages." Once, when Agassiz was away upon one of his scientific excursions among some remote, semicivilized peoples, Holmes remarked: "I cannot help thinking what a feast the cannibals would have, if they boiled down such an extract!" A gentleman once commented very unfavorably upon this jest, explaining, with more than British gravity, that it was a poor one because cannibals don't care for wisdom and would only have relished Agassiz because he was plump!

Of all Agassiz' associates in the Saturday Club, none was so close to him as Longfellow. These two friends were almost forty years old when they met, an entry in

Longfellow's *Journal* of January 9, 1847, noting the meeting thus:

> In the evening, a re-union at Felton's, to meet Mr. Agassiz, the Swiss geologist and naturalist. A pleasant, voluble man, with a bright, beaming face.

Less than a month later, references to Agassiz are made without the title, for the two had already become intimate. Visitors to Longfellow's "Craigie House" noticed the cordial relations between the two friends. Thus, Robert Ferguson, of Carlisle, England, in giving an account of his visit in 1864 writes:

> .... And often, too, comes Agassiz, with his gentle and genial spirit, his child-like devotion to science, and—or he would not be a true son of his adopted country—his eager interests in the politics of the day. We went to hear one of his lectures at the University,—not one of what are considered the popular lectures, but one of a special course to a small class. Yet it was deeply interesting .... Between the Poet and the Naturalist there exists a very warm friendship, and among other poetical tributes, Mr. Longfellow has achieved the feat—for so it must seem to us, with our rigid English tongues—of addressing to his friend, in the October number of the *Atlantic Monthly*, a gay and graceful chanson in his native language.

Longfellow also included a sonnet to Agassiz in the group entitled "Three Friends of Mine."

In spite of the fact that Emerson's mind was far from being of the scientific pattern, he and Agassiz were the most genial of friends. Emerson's prejudice against science is shown in his poem "Blight," in which he complains that the "young scholars who invade our hills"—

> Love not the flower they pluck, and know it not,
> And all their botany is Latin names. ...

Further, it is not improbable that Emerson's genial companionship with Agassiz, with his conception of Nature as "thoughts of the Creator" and his delightful social qualities, gave him a kinder feeling toward men of science and their pursuits than he had entertained before he met Agassiz. That Emerson appreciated Agassiz is attested by several entries in his *Journals*, three of which we shall quote. In 1864 on the occasion of a visit from Stanley, Phillips, Channing, Alcott, and Agassiz, he writes:

> Agassiz is really a man of great ability, breadth, and resources, a rare and rich nature, and always maintains himself,—in all companies, and on all occasions. I carried him to Mrs. Mann's, and afterwards, to Bull's, and, in each house he gave the fittest counsel in the best way. At the Town Hall, he made an excellent speech to the farmers, extemporaneous, of course, but with method and mastery, on the question of the location of the Agricultural College, urging the claims of Cambridge.

In 1866, he visited Agassiz at Nahant and reported:

> He is a man to be thankful for, always cordial, full of facts, with unsleeping observations, and perfectly communicative.

In 1869, in describing Agassiz' address at the Humboldt Centennial Celebration, he concludes with the following evaluation of Agassiz:

> He is quite as good a man as his hero, and not to be duplicated, I fear. I admire his manliness, his equality always to the occasion, to any and every company,—never a fop, never can his manners be separated from himself.

In the summer of 1858 Emerson, Agassiz, Lowell, Wyman, William James, Stillman, and five others set up a "Philosophers' Camp" in the Adirondacks. Longfellow refused to go because he feared Emerson carrying a gun. Stillman has left a faithful painting of the first camp of the Adirondack Club, which now hangs in the Concord Public Library. Agassiz is one of a trio dissecting a fish. Stillman is instructing a quartette, including Lowell, in the use of the rifle. Emerson stands alone in thought. Emerson has enshrined this sojourn in the

wilderness in a poetic chronicle entitled "The Adirondacks."

Lowell confessed that he understood and liked Agassiz better as he himself grew older and perhaps less provincial. He was in Florence when Agassiz died and wrote a long poem in the nature of an elegy on Agassiz. In a letter to C. E. Norton dated February 26, 1874, he related how he came to write the verses:

> His death came home to me in a singular way, growing into my consciousness from day to day as if it were a graft new-set, that by degrees became part of my own wood and drew a greater share of my sap than belonged to it, as grafts sometimes will. . . . It was curious to me after it was done to see how fleshly it was. This impression of Agassiz had wormed itself into my consciousness and without my knowing it had colored my whole poem. I could not help feeling how, if I had been writing of Emerson, for example, I should have been otherwise ideal. But there it is, and you can judge for yourself. I think there is some go in it somehow, but it is too near me yet to be judged fairly by me. It is old-fashioned, you see, but none the worse for that.

The last eleven lines of Lowell's long poetic tribute to his friend can well serve to summarize Agassiz' magnetic power over people:

> We have not lost him all; he is not gone
> To the dumb herd of them that wholly die;
> The beauty of his better self lives on
> In minds he touched with fire, in many an eye
> He trained to Truth's exact severity;
> He was a Teacher; why be grieved for him
> Whose living word still stimulates the air?
> In endless file shall loving scholars come
> The glow of his transmitted touch to share,
> And trace his features with an eye less dim
> Than ours whose sense familiar wont makes numb.

ADVANCE REGISTRATION

114TH MEETING OF THE A.A.A.S., CHICAGO, DECEMBER 26–31, 1947

Those planning to attend the Chicago Meeting of the Association, December 26–31, may register now by sending the correct registration fee ($2.00 for members and college students, $3.00 for nonmembers) to the Washington office of the Association, 1515 Massachusetts Ave., N. W. The *General Program* will be mailed on December 1 to all who register before that date, in time to study its contents and decide at leisure which of the many hundreds of sessions and special functions they may most profitably attend. Moreover, they will be saved the time of registering during the meeting, and their names will be included in the special directory of registrants that will be available for inspection in all the headquarters hotels.

The *General Program* will list the papers of the sections and societies meeting with the Association, including the time and place of each session. It will also contain announcements regarding general sessions, the International Science Exhibition, eating facilities, transportation, mail and messenger service, and a directory of speakers and presiding officers. Readers will find the Summary of Sessions most useful.

Registration fees have been received since August 15, and they will be accepted for mail distribution of the *General Program* until December 10. Payments received after that date will be held and placed on file on December 26 at the main registration center located adjacent to the Exhibition in the Stevens Hotel. Upon identification, registrants will be given a copy of the *General Program*, and their registration cards will be placed in the Visible Directory. To avoid delay in receipt of your copy of the program during the Christmas mailing rush, please send your registration fee in time for it to reach the Washington office before December 1.

Book Reviews

MANKIND CREEPS SLOWLY ON

Science Advances. J. B. S. Haldane. 253 pp. $3.00. Macmillan. New York. 1947.

IN THIS collection of about seventy short, informative essays, Professor Haldane presents a rich variety of scientific topics, with illuminating comments on the social significance of science and of scientists. Some of the essays have been reprinted from periodicals not likely to be on the general reader's list, and are doubly welcome on that account. The eight sections of the book treat Some Great Men (ten scientists); Animals and Plants; Human Physiology and Evolution (two sections); Medicine; Hygiene; Inventions; Soviet Science and Nazi Science; Human Life and Death at High Pressures—all with the firm touch of the man who knows whereof he writes.

The preface is a candid apology in reverse for fitting the facts described into a general framework of Marxism. The fitting is done so unobtrusively that no sclerotic member of any Committee on Un-American Activities, reading the essays, need anticipate death from high pressure. Dialectical materialism is described as a "method of thought and action," and its prophets are quoted. Some, of course, will deplore this temperance, preferring Bertrand Russell's sacrilegious lexicon of Communism, which equates Yahweh to Dialectical Materialism and Hell to the Punishment of the Capitalists.

As may be inferred from the titles of the sections, the book is mostly about the life sciences and their human importance. There have been several excellent accounts of the physical sciences for the general (and professional) reader; these essays are a complement for the life sciences. The common cold, causes of cancer, the drink trade, cosmetics, X-rays and their dangers, and many other topics of importance to professionals and laymen alike are plainly and interestingly presented. Dozens of books have been written on the conflict of science and theology. The following statement of fact (p. 131) says more than the lot of them: "A wedding-ring does not prevent venereal infection."

E. T. BELL

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THINGS TO COME

The Future of Television. (Rev. ed.) Orrin E. Dunlap, Jr. xi + 194 pp. $3.00. Harper. New York. 1947.

MR. DUNLAP'S book is not a technical book on the subject of television but deals chiefly with its economic, social, and artistic aspects. These topics are not treated in a sufficiently coherent manner, however, and many good thoughts are put together in a mosaic fashion.

The mutual effects of television and such media as the theatre, the films, and sound broadcasting upon each other are plausibly treated, though necessarily in a speculative vein. A very brief history of television is given, together with a condensed explanation as to how it works. Unfortunately, almost the entire book deals with the state of the art up to the outbreak of World War II. Only the last few pages mention what has happened during the past two important years.

Possibly owing to the author's affiliation

with RCA, the reader is presented with an overwhelming array of RCA achievements, to the partial exclusion of contributions from other sources. As an example, nothing is mentioned of the pioneering in the field of color television by the Columbia Broadcasting System. Instead, the author attaches too much significance to the statements of those in the industry who play down the importance of color in the movies and in television.

The Future of Television can, at best, give the reader only a sketchy acquaintance with the types of problems that confront television today.

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FOR STARGAZERS

Making Your Own Telescope. Allyn J. Thompson. xi + 211 pp. Illus. $3.50. Sky Pub. Cambridge, Mass. 1947.

FIFTY years ago, the great popularizer of astronomy, Garrett P. Serviss, wrote that if the pure and elevated pleasure to be derived from the possession of a good telescope were generally known, no instrument of science would be more commonly found in the homes of intelligent people. Today, thanks to the telescope-making movement, the means of exploring the wonderlands of the astronomer are within the reach of everyone, and hundreds of people of all ages are scanning the heavens with instruments of their own making.

Mr. Thompson has guided many novices in the exacting but fascinating work of grinding and figuring mirrors for reflecting telescopes. His volume explains all the steps, from the assembly of the materials needed for the mirror to the adjustment of the finished telescope. This is done so clearly and reasonably, and with such carefully prepared diagrams, that a lone amateur with no previous knowledge of optics could produce an effective instrument. In fact, the new observatory director, after a pleasant period of becoming familiar with the more glamorous celestial wonders, may even use his telescope to add to scientific knowledge by systematic observations of variable stars, sunspots, and occultations of stars by the moon.

The opening chapter gives the history of the development of the telescope. This will inspire the tyro by giving him an appreciation of the significance of his undertaking. The major portion of the book is, of course, devoted to the attainment of the elusive parabolic surface of the main mirror, where the difference between perfection and mediocrity is a matter of but a few millionths of an inch. Successive chapters deal with the diagonal, tube, mounting, eyepieces, and practical observing information. A chapter entitled A Second Telescope is wisely included. This reviewer has helped dozens of telescope makers, using Mr. Thompson's original articles as reprinted from *Sky and Telescope* as reference. In nearly every case, the student begins to plan his second telescope before the first is even completed. The thrill of the first observations with a new telescope is actually a major experience in the life of its maker.

WILLIAM A. CALDER

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SOME REMARKS ABOUT AGRICULTURE

Jesse Buel: Agricultural Reformer. Harry J. Carman, Ed. xxxvi + 609 pp. $6.75. Columbia. New York. 1947.

THIS volume, the twelfth in the series of studies published by Columbia University on the history of American agriculture, is devoted to the lifework of Jesse Buel, a self-educated pioneer, born in Coventry, Conn., in 1778. With the benefit of only six months' schooling Buel began

his career in a Vermont printing office at the age of twelve. Within a few years he became a journeyman printer in New York City, later embarking on an extensive newspaper career in Lansingburg, Kingston, Poughkeepsie, and finally Albany, where he established the *Argus*, his fifth and most successful newspaper. His untiring industry and shrewd business acumen soon brought him funds sufficient to warrant the devotion of the rest of his life to reform of farming methods by well-planned experiments.

To that end he purchased eighty-five acres of poor soil in the "Sandy Barrens" just west of Albany, where he at once put into practice methods of tillage and seed selection and systems of crop rotation whereby he increased the yield manyfold in all crops, particularly in corn and potatoes.

Buel's remarkable success promptly attracted the attention of his farm neighbors, and his fame spread, not only in the United States, but to various European countries. The practices on his own farm, as well as the changes in farm methods that he recommended far and wide for the improvement of American agriculture, were based on his own experiments and the published scientific results of tests made in England, Scotland, Holland, and Germany.

So sure was he of his own discoveries and so impressed with the need of sound adult education for farmers that he gave generously of his time to lecturing, organization of agricultural societies, and to writing short, timely articles for the farm journals. A more pretentious undertaking was the preparation of a volume entitled *The Farmer's Companion*, dealing with the multitudinous problems the farmer has to meet.

Perhaps the most striking impression derived from reading the voluminous writings of this journalist, editor, farmer, lecturer, and philosopher of a century ago is the high percentage of his specific recommendations that might be applied with advantage to the average farm today. Indeed, his system of management of pastures and meadows is fully abreast of the best modern practices. Buel was a prophet as well as a pioneer.

E. V. WILCOX

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POPULAR SCIENCE

Physical Science in Art and Industry. E. G. Richardson. xi + 299 pp. Illus. 15/—. English Universities Press. London. 1947.

IN THIS book Dr. Richardson continues his lively discussions of the practical contributions of physics, with examples somewhat more advanced than those presented in his earlier *Physical Science in Modern Life*. The result is a book of scientific popularization whose maturity and versatility commend it equally to the general reader and to the physicist. Each will find stimulating extensions of his special interests—often with unexpected parallels—in the physics of locomotion, communication, pottery, culinary art, farming, hydrology, mining, fine arts, building construction, music, and textiles.

The author writes in an agreeable conversational style about subjects that have interested him, to many of which he has made original contributions. Mathematics is not used, but graphs of characteristics and performance are frequently presented.

One might wish that the line drawings had been done in uniform style and that more recent illustrations directly applicable to the text had been included. The general appearance of the book is pleasing, however.

The exposition is authoritative. Principles probably unfamiliar to the general reader are presented clearly and simply without misleading analogies.

The author takes a long-range viewpoint, often leading to interesting brief historical digressions. But there is little that savors of a philosophy of science or

concern about the social responsibilities of scientists. The wartime advances of physics are relegated to a single eleven-page chapter. Nuclear energy is not mentioned.

Occasionally, practices of long standing are alluded to as recent developments. Speaking of tube railways, the remark is made that sections 180 feet long and welded in one piece are now being tried. The equable temperature maintained underground makes it unnecessary to allow for expansion to the extent that is necessary in surface railways. One would not suspect from Richardson's account that sections of welded rail a mile or more in length have been used on U. S. railroads for decades, with rails subject to harmless stresses without displacement during the usual changes of temperature.

This book contributes pleasantly to the enlargement of the reader's interest in a wide range of phenomena whose understanding and control are aided by the methods of physics, often rather simply applied.

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THE NAVAHO

Children of the People. Dorothea Leighton and Clyde Kluckhohn. xi + 277 pp. Illus. $4.50. Harvard. Cambridge, Mass. 1947.

IN SEPTEMBER 1941 an Indian Education Research Project was undertaken jointly by the United States Office of Indian Affairs and the Committee on Human Development of The University of Chicago. The aim of the program was to examine five tribes anthropologically, psychologically, and medically, in the hope that the data thus accumulated would help to increase the effectiveness of Indian administration in the future. The task of studying the Navaho, largest and most rapidly increasing tribe in the United States, was entrusted to two outstanding specialists; their findings are embodied in *Children of the People.*

Since both investigators had done much previous field work among the Indians in question, they wisely decided to publish their material in two complementary volumes. An earlier book, entitled *The Navaho* [SM, May 1947, 442], presents a broad picture of the tribe's environment and customs and provides a background for the present study of Navaho upbringing and personality development.

The first four chapters constitute Part I and were prepared by Professor Kluckhohn. They give an authoritative and interesting account of the major phases through which a Navaho individual passes on the journey from birth to death. Much emphasis is placed by the author on child training and its effect on the formation of personality traits. Somewhat unexpectedly, it was found that adult tribesmen show quite a bit of tension and worry in spite of the fact that as infants they had received a maximum of protection and gratification.

Dr. Leighton, who is responsible for the remainder of the book, deals with the data that were secured expressly for the Indian Education Research Project. On the basis of medical and psychological tests administered to 211 children drawn from three communities, it became apparent that all the Navaho tend to exhibit fairly similar personality patterns. Taken as a group they appear to be a practical folk, alert to the values of individuality, and endowed with energy, vitality, imagination, and high artistic capacities. Outwardly poised, and not prone to feelings of guilt over undiscovered misdeeds, they are nevertheless sensitive to criticism and ridicule. Although they are moody on occasion, they have a keen sense of humor and generally get much enjoyment out of life.

Both parts of *Children of the People* are so well written and illustrated that they

deserve to be widely read. Professional anthropologists and psychologists may disagree with some of the theoretical positions taken by the authors, but it will be universally agreed that Leighton and Kluckhohn have made available much fresh and valuable information about one of the most colorful tribes in North America.

MISCHA TITIEV

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OF SHOES—AND SHIPS—AND SEALING WAX

The Origin of Things. Julius E. Lips. 496 pp. Illus. $5.00. A. A. Wyn. New York. 1947.

LEST we become overweening in our pride in the achievements of our age, Dr. Lips gives us impressive anthropological proof of the inventiveness of primitive peoples in all parts of the world. Nearly everything we value now seems to have been known in some form in earlier times. For instance, "the animal trap invented by primitive man has opened so many roads to modern technological development that no one who has followed the development of this first robot will deny its overwhelming importance."

Fact leaps upon fact in this well-ordered volume, and is enlivened by occasional philosophical comment on the culture under discussion. Whether it be cosmetics and body adornment, hunting, agriculture, architecture, history of the drama, medicine, or religion, it is told in vividly detailed style. Dr. Lips writes entertainingly but keeps his science ever in sight. To add additional clarity there are some fairly good photographs and more than 300 often small, but definitely superb, drawings by Mrs. Lips.

The book is enriched too by brief anecdotes of the manners and customs of aborigines: Among the Buryats of Asia "blacksmiths are the cream of society," whereas in Tibet they are "members of the lowest caste." No party among the Indians of Paraguay would be complete without the "tea wrongly known as mate." Since "paleolithic times Asia and Europe knew [ice] skates manufactured from bones." Occasionally "inflation threatens a primitive tribe—just as in our civilization." In the "African Pangwe country lightning is a 'black ball' which leaves its 'excrements' on the trees it hits in the form of resin, which is worshiped as holy."

In the next to the last chapter of the book are primitive fables in explanation of natural phenomena; they round out and enhance the preceding discussions. Finally, there is an extensive bibliography and an index.

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AL THIS NEWE SCIENCE THAT MEN LERE

The Strange Story of the Quantum. Banesh Hoffmann. xi + 239 pp. $3.00. Harper. New York. 1947.

THIS is an ambitious book. Without being technical, without using mathematics—which is the tool of reasoning and of explanation—the author tries to convey to the reader the fascinating story of quantum theories, including such difficult concepts as phase velocity, the algebra of matrices, Pauli's exclusion principle, the operational calculus, and many others. Comparison, analogies, whimsey—all these devices of popularization are used. The narrative is often interrupted by interesting historical remarks woven into the story. Another device, which was developed by Jeans into an art of popularization, is used here, though fortunately in moderation. This device consists in jumping from physics into metaphysics, in creating metaphysical thrills, and in raising the emotions over the

"mysteries" of the universe. Thus, we read in Hoffmann's book (p. 189): "And towering majestically over all, inscrutable and inescapable, is the awful [why awful?] mystery of Existence itself, to confound the mind with an eternal enigma;" or, again, on page 231: "If the mind of a mere Bohr or Einstein astounds us with its power, how may we begin to extol the glory of God who created them?" Many readers will like such metaphysical and religious passages. Those who don't will find enough in the bulk of the book to enjoy it in spite of occasional too-fancy writing. Yet there is one question which, unfortunately, I am unable to answer. Will a reader who does not know anything about quantum theory gain an understanding of the ideas the author tries with considerable skill to explain? My answer to this question is: I hope so, but I am not sure.

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THE ATOMIC STORY

Atomics for the Millions. Maxwell Leigh Eidinoff and Hyman Ruchlis. xiv + 281 pp. Illus. $3.50. McGraw-Hill. New York. 1947.

IMMEDIATELY after The Bomb, there was a rash of hastily prepared and thoroughly inadequate books on atomic energy, and one monumental report—the Smyth Report. The first group had little or no understanding or background; the Smyth Report required that the reader have considerable background to understand it.

Beginning early this year, a second crop of atomic-energy books has appeared, all intended for public consumption, and all on a far higher level of understanding than the rush books of late 1945.

Atomics for the Millions is a new addition to this latter group of well-planned, well-written books with real understanding of the subject. Dr. Eidinoff was directly attached to the Manhattan District at Columbia University, at the University of Chicago site, and with the Kellex Company, who built much of the actual equipment. He knows the processes involved and the atomic side of the problem. Hyman Ruchlis is an educator, a science instructor, and has done much work in improving science courses in high schools. The teamwork of these two men is accurate, straightforward presentation of the opening of the atomic age, told in language adapted to both high-school students and the general public.

Properly, the book starts by explaining how we discovered atoms exist, how we determined that energy was there to be tapped, and how the first man-made transmutations were brought about. The discussion of the Manhattan District occupies about a third of the book in English language, without resort to Technicalese, a language foreign to those not brought up in its native habitat—the laboratory.

The last sixth of the book is devoted to a discussion of probable peacetime applications of atomic energy, methods of application, difficulties to be encountered, and the extent of available reserves of atomic fuels.

The influence of the professional educator is clear in this book in two respects. The first is the marked success in straining out the unnecessary polysyllabic, special-meaning words so useful to the professional scientist, but so confusing to the non-professional. The second is a somewhat less desirable effect; the short-sentence formula style of the pedagogical textbook did creep in, making a rather humorless though clear and accurate presentation.

The plentiful semicartoon illustrations by Maurice Sendak are excellent and extremely helpful in understanding the happenings in nuclear physics.

JOHN W. CAMPBELL

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PLANTS THROUGH THE AGES

Ancient Plants and the World They Lived In. Henry N. Andrews, Jr. ix + 279 pp. Illus. $4.50. Comstock Pub. Ithaca, N. Y. 1947.

FEW books of strictly scientific information are as interesting and readable as Dr. Andrews' concise volume on ancient plants. Actually, the book is more than the title implies, for its content is not confined to discussions of plant fossils, but is really a series of treatises on the evolution of various plant groups from their first known beginnings in past ages to their modern descendants. Included also are related topics, such as the constitution of coal, climates of past ages as indicated by fossils, genealogies in the plant kingdom, and a short review of the development of paleobotanical science.

Throughout the volume one runs across such philosophical musings as only a scientist might utter. For example:

> The club mosses whose ancestors we trace back at least 300 million years are still a vigorous element of our living flora. Who can say, after he has seen them spreading like a carpet over the floor of our eastern woodlands, that these plants are approaching extinction? To be sure, they are not the masters that their Carboniferous forebears were, but shall we judge plants simply by their size? It is well-known that our own ancestors of the so-called Dark Ages were but disagreeable reminders of their highest levels of achievement of previous centuries. But we rose from that awful period of stagnation, and it is not impossible that such cycles will be repeated in the future (p. 161).

No errors of consequence, such as occasionally creep into scientific volumes, have been noted except in connection with the photograph of Roaring Mountain in Yellowstone National Park (p. 7). The statement is made that this modern hillside has been devastated by volcanic activity, whereas the devastation has been by thermal activity. Actual volcanism has long since ceased in Yellowstone. The serious reader will regret that the excellent reproductions of fossils, the line drawings, and the photomicrographs carry no indications of their relative reduction or enlargement. Others, as well as myself, may wonder also why the author has chosen to discuss *Lepidodendron* as the only significant lycopod tree of the Carboniferous forests, ignoring completely such equally important ones as *Sigillaria* and the relatively abundant *Lepidophloios*, and possibly others.

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MAN OF GENIUS

Sun, Stand Thou Still. Angus Armitage. 224 pp. Illus. $3.00. Schuman. New York. 1947.

NICHOLAS COPERNICUS, trained chiefly in law and medicine, spent his life in the midst of the practical administrative problems of a canon of the Catholic Church in Poland. How could such a man produce a treatise on astronomy, *De Revolutionibus Orbium Celestium*, which ranks as one of the most important scientific books of all time? For that matter, how could Ptolemy produce the *Almagest*, or Newton the *Principia*, or Darwin the *Origin of Species*? An explanation of genius probably cannot be written; if written, it would not be understood. A part—the perspiration part—of the method of genius, however, is clearly described in Mr. Armitage's book. *De Revolutionibus* was no quick brain storm whipped up in a couple of weeks; it was the result of decades of patient, intelligent application.

The book under review falls naturally into three parts. The first part recounts the efforts of the early astronomers to systematize the apparent motion of celestial bodies and then explains the status of the problem at the time of Copernicus. The second part, which comprises the central half of the rather small volume, tells the

life story of Copernicus; it sets forth the particulars that have come down to us concerning the writing and printing of *De Revolutionibus* and gives a general account of the basic ideas in this historic document. The last part traces the principal stages in the establishment of the heliocentric system in the minds of men.

A typical paragraph, the first one in Part 3, follows:

> In these concluding chapters, we shall try to round off the story of Copernicus by giving some account of how his main ideas have come to be accepted as true. It is, of course, impossible to say how long this process took to accomplish. There were some people who accepted the Copernican theory right away. On the other hand, there may still be some cranks who maintain that the earth is fixed in space and that the heavenly bodies revolve round it. But we shall not be far wrong if we assume that the last traces of serious opposition were swept away by Newton. And as his great book appeared in 1687, we may, perhaps, take one hundred and fifty years as roughly the length of this important stage in the growth of astronomy.

The simple, lucid style, quite devoid of technical terms, and the short, well-spaced lines of type make for easy reading.

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WAXES

Adventures in Man's First Plastic. Nelson S. Knaggs. xiv + 329 pp. Illus. $6.75. Reinhold. New York. 1947.

THE subtitle of this book is "The Romance of the Natural Waxes." It is fully justified by chapters on Expedition to the Amazon (cauassu wax); Brazil's Tree of Life (carnauba wax); Exploring the Big Bend (candelilla wax); On to Mexico (candelilla wax); Submarine Treasure (whaling industry and spermaceti wax); The Little Lady Lac Bug (shellac wax); Ouricuri, The Ant Killer Tree (ouricury wax); The Esparto Harvesters of North Africa (esparto wax); The Mysterious Bee, Famine Fighter of Mankind (beeswax); A 60,000 Year Old Plastic (ozokerite wax); Wax from Ancient Forests (montan wax); and White Crystals from Black Gold (paraffin wax). There are many pages of rotogravure illustrations, a chapter on Wax Through the Ages, a short technical reference section on natural waxes, a bibliography, and an index, all testifying to the immense amount of work that has been put into the volume.

Besides accounts of beeswax and other insect waxes, there are stories of those obtained from the leaves of plants, from sperm whales, and from petroleum, lignite, and other deposits found in various parts of the world.

As the title implies, the book includes the fascinating history of ancient and modern man's search for these products, their extraction and processing, as well as the many uses made of waxes from the late Stone Age to the present time. An intimate picture is presented of various regions, the inhabitants, their beliefs, character, and their industries. Much information is interwoven with the stories of the waxes concerning the uses made, for example, of various parts of the carnauba palm, esparto grass, and whales. This information about the waxes and their uses is particularly good, but I noted that the unique liquid wax of the jojoba shrub (*Simmondsia californica*, Buxaceae) was not mentioned. I noted also that the bibliography does not list the book by H. Bennett, entitled *Commercial Waxes* (Brooklyn: Chemical Pub., 1944).

It would have been desirable to describe, as was done in the case of bayberry wax, the others which are also fats, including Japan wax, ucuuba, and that from murumuru palm kernels.

The book is very informative, however, and is written in a style that may be enjoyed by everyone.

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MAMMALOGY

Mammals of North America. Victor H. Cahalane. x + 682 pp. Illus. $7.50. Macmillan. 1947.

MR. CAHALANE sets out to summarize in popular form the existing information about the lives and habits of North American mammals. The result is a readable, charmingly illustrated book that should be of great interest to nature lovers, sportsmen, and the many country dwellers whose lives are affected by the activities of local wildlife.

Conspicuous forms are treated separately, less spectacular or more closely related ones, as groups. In general, each account includes figures on the reproductive cycle, care of the young, growth and development, shelter and nest building, mating activity, diet and the securing and storage of food, range and territoriality, seasonal activity, enemies, economic importance, and many odd and interesting bits of information about such things as singing in mice and the poison glands of shrews. Brief, general descriptions as well as ranges are also given. One of the most pleasing features of the book is the author's usually very successful attempt to make each animal a really living creature. In avoiding the dull and too-impersonal writing of many recent life histories, some of his humanizing strikes a false note, but in general the reader will feel that the different animals actually have a personality as well as habits and an appearance. In this respect his accounts of individuals, such as the story of a female cougar hunting deer at sundown, or of a young muskrat in the autumn searching for a home territory, are particularly successful. One of the most valuable contributions of the book is the discussion of the economic importance of various groups. The need to maintain a balanced population is well and convincingly stressed.

Both the text and the good, but admittedly incomplete, bibliography show a wide background of reading, though the sources of information are seldom given. In general, this makes for an easy style, well calculated to catch and hold popular attention, and when dealing with forms whose habits are well known the method is entirely satisfactory. Occasionally, when Cahalane is writing about less well-known forms or when he uses controversial material, the specialist would like to know the authority for certain statements.

A book of this sort should have a wide popular circulation, and it is a pity that the high price will inevitably limit it. Perhaps it would have been better to bring it out in two less expensive volumes.

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ENCYCLOPEDIA

Van Nostrand's Scientific Encyclopedia. (2nd ed.) 1,600 pp. $12.00. Van Nostrand. New York. 1947.

SOME 11,000 topics, arranged alphabetically and elaborately cross-referenced, appear in the present edition of this one-volume encyclopedia. There are some 1,500 diagrams and photographs.

As in the first edition, the main fields covered are mathematics; the physical, earth, and biological sciences; the chief fields of engineering; and medicine. The format of the first edition has also been retained. But the number of contributing and consulting editors has risen from 21 to 40, and the number of pages from about 1,200 to 1,600. There are new sections on electronics, radio, metallurgy, meteorology, photography, and statistics. At least 1,000 entries have been added, and many of the original articles have been revised, often only in small details that nevertheless increase their accuracy and readability. Many articles have been expanded; a few—for instance, those on *Aerodynamics* and

Steel—are several times their former length.

The topics range from the most familiar—*Bedbug, Berry, Cement, Dog, Evaporation*, . . .—to many that are highly technical—*Bernoulli probability function, Dynamical parallax, Gamma function, Pholidota*, . . . Many of the topics are treated in only a few lines—for instance, those on *Lanceolate, Luth, Phimosis, Radiothorium, Veering wind*. Some cover half a dozen or more pages—as with *Algae, Amines and amides, Chemical composition, Hydrocarbons*.

Also as in the first edition, the treatment of most topics is progressive in difficulty, beginning with a simple definition or explanation and passing on to more detailed, technical considerations. As might be expected when different authors and different fields are represented, the treatments range from the fundamental and analytic to those containing mainly factual details. For only a few of the main fields are there articles that give a broad outline of the structure, branches, and chief characteristics of the field. Only for geology and chemistry are there separate articles on the histories of the sciences. However, the article on *History and evolution of chemistry*, in five and one-half pages, helps to make up for this deficiency in historical treatment of related fields by including a list of Nobel prize awards in physics, physiology, and medicine; by listing as developments in "pure chemistry" the work of Kirchhoff on blackbody radiation, of Maxwell on electricity and magnetism, of Millikan on the electronic charge, and so on; and by putting under "applied chemistry" such items as Edison's development of the carbon filament lamp and De Forest's invention of the triode detector. Never should so patent an effort to further the unification of knowledge be allowed to pass unmentioned.

In reliability and comprehensiveness, this encyclopedia is far superior to the usual run of popular reference books. It is true that the responsibility for each broad field was in the hands of only one or two scientists, who had help from several consultants in the field. But as one result there is considerable unity among the many different articles in any given field.

The book should prove to be especially useful to college students of the sciences, to science teachers in the schools, and to educated laymen who need to have ready access to technical information.

DUANE ROLLER

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MUCH has been written and spoken about the responsibility of scientists to society. It is their responsibility, some people believe, to see to it that their new knowledge, which is power, is used only for beneficent purposes. In the August issue of the SM Professor Bridgman argued that scientists should not accept such responsibility, that they cannot do so and remain productive scientists. So far as "pure" scientists are concerned, Professor Bridgman is certainly right. It is ridiculous to suppose that the discoverer of a new principle could envisage all possible applications of it, and, even if he could foresee its detrimental potentialities, that he could prevent undesirable exploitations. Indeed, he may be in an honored grave long before his discovery has been made to plague society. Applied scientists, however, probably should do what they can, within reason, to control the use of their developments and inventions: through the patent system, through advice to industrialists and politicians, and through education of the public. But the real responsibility for the uses made of scientific developments must be placed upon society as a whole, of which scientists are a small part. Or one might say that our culture determines the course of science and the uses made of scientific discoveries. Individuals may really be helpless in the grip of our existing culture but, I think, they must act as if their efforts could direct its change toward desirable ends.

Assuming that education of the public not only transmits but modifies our culture, it should be desirable for both pure and applied scientists to report not only to fellow-scientists but to the general public, who, directly or indirectly, have made their work possible. It is not an exhibition of modesty but of selfishness when a scientist refuses to take the time or make the effort to keep the public informed about the progress and results of his work. He should cooperate with reliable news services. Large scientific societies, institutions, government agencies, universities, and industrial research laboratories employ writers to prepare reports of scientific progress for the press. It would be interesting to know to what extent these press releases are utilized. Certainly they serve to inform science editors and writers of much current progress and, if not used as written or rewritten, can lead to interviews and stories by science writers of newspapers and magazines. Whether he does or does not have the benefit of a press service within his own institution, agency, or society, a scientist should cooperate directly with professional science writers at every legitimate opportunity.

Of particular interest to us is the opportunity provided at A.A.A.S. meetings for cooperation between scientists and science writers. Every paper to be presented at the Chicago meeting should be made available to science writers through our press service in advance of the meeting in the form of an adequate abstract, complete manuscript, or both. The characteristics of an adequate abstract, from the point of view of a science writer, are described in this issue by Herbert B. Nichols, Science Editor of the *Christian Science Monitor*. Bear in mind, however, that some information delivered on time is better than complete information that comes late. I might add also that complete manuscripts thought suitable for publication

in the SM may be submitted to me well in advance of the meeting. Those accepted may be published early in 1948.

We should face the fact that science writers cannot make news out of every paper to be presented at the Chicago meeting. They know by experience the kinds of stories acceptable to their editors and, presumably, to the readers of their newspapers. Owing to the tendency of the public to personify every field of activity in terms of "stars," a few distinguished scientists have been well publicized. Their reports and pronouncements are therefore most newsworthy, and the science writers are most eager to get complete manuscripts of their addresses *in advance*. The work of other scientists who are not already known to the public is judged by its probable significance to public welfare and interest. Putting himself in the place of the lay reader, the science writer, examining a scientific report, asks: "How may it affect my daily life and thought? What does it mean to me?" Thus applied science is likely to be more productive of news than pure science, although pure science, insofar as it touches a philosophy of life or points to possible applications in war or peace, may have a great appeal. And finally there are the curiosities of science that are sufficiently within the experience of laymen to be called interesting for their own sake. Although his work may seem to have no popular significance, let no scientist assume that it is without news value. If he will prepare his abstract as recommended by Mr. Nichols and deliver it on time, he may be surprised to find that there is a story in it for science reporters. If not, he will have the satisfaction of having done his best to report back to the public.

Those who have time to read books written by scientists probably get the clearest and most comprehensive view of the development and significance of scientific work. Our Assistant Editor, Mrs. Keener, who has been in charge of our Book Review section for the past year, is publishing reviews of the more popular scientific books as they appear. The present issue is to be regarded as our Winter Book Issue. Planned largely by Mrs. Keener, it features articles on special scientific libraries, just as the Spring Book Issue emphasized the work of the university presses. Hereafter, however, we expect to have but one book issue each year, probably in the fall. In addition to presenting a special theme concerning scientific books, each book issue will contain articles relating science to the humanities; e.g., Bradford Willard's article in this issue on "The Geology of Shakespeare."

The December issue of the SM may well be called the Convention Issue. Chicago is certainly one of the most important scientific centers in the United States. It is a center not only of scientific research but of scientific education through its universities and museums. The December issue will inform the reader of the wealth of scientific activity in the Chicago area, with particular emphasis on the new research institutes of The University of Chicago. Special articles by Chicago scientists will complete the issue. We hope that our Convention Issue will help to draw to Chicago the largest group of scientists that ever attended an A.A.A.S. meeting. There is much to see and learn in Chicago. Remember the dates—December 26–31, 1947—and request your hotel reservations now!

F. L. CAMPBELL